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BAKER (MICHAEL) JR INC BEAVER PA
NATIONAL DAM INSPECTION PROGRAM. LIGONIER DAM (NDI NUMBER PA-00-ETC(U)
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OHIO RIVER BASIN
SOUTH FORK OF MILL CREEK, WESTMORELAND COUNTY
PENNSYLVANIA

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LIGONIER DAM

NDI No. PA 00477
PennDER No. 65-117

LEVEL

PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM

MICHAEL BAKER, JR., INC.
DACW31-80-C-0020/0025



prepared for

DEPARTMENT OF THE ARMY
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

prepared by

MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

March 1980

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OHIO RIVER BASIN

LIGONIER DAM
WESTMORELAND COUNTY, COMMONWEALTH OF PENNSYLVANIA
NDI No. PA 00477
PennDER No. 65-117

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

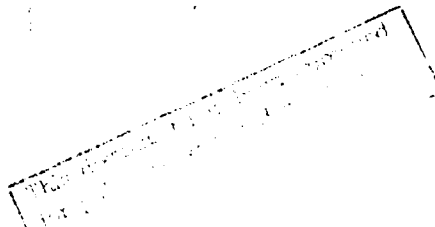
Ligonier Dam (NDI Number PA-00477,
PennDER Number 65-117), Ohio River
Basin, South Fork of Mill Creek,
Westmoreland County, Pennsylvania, Phase I

Prepared for: DEPARTMENT OF THE ARMY Inspection Report
Baltimore District, Corps of Engineers
Baltimore, Maryland 21203

Prepared by: MICHAEL BAKER, JR., INC.
Consulting Engineers
4301 Dutch Ridge Road
Beaver, Pennsylvania 15009

(12) 971 (15) DAZW 31-80-C-0025

(15) John A. Dziubek



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In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with data available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action, while improving the stability and safety of the dam, removes the normal load on the structure and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

Phase I Inspections are not intended to provide detailed hydrologic and hydraulic analyses. In accordance with the established guidelines, the spillway design flood is based on the estimated "Probable Maximum Flood" for the region (greatest reasonably possible storm runoff), or fractions thereof. The spillway design flood provides a measure of relative spillway capacity and serves as an aid in determining the need for more detailed hydrologic and hydraulic studies, considering the size of the dam, its general condition and the downstream damage potential.

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PHASE I REPORT
NATIONAL DAM INSPECTION PROGRAM

Ligonier Dam, Westmoreland County, Pennsylvania
NDI No. PA 00477, PennDER No. 65-117
South Fork of Mill Creek
Inspected 11 December 1979

ASSESSMENT OF
GENERAL CONDITIONS

Ligonier Dam (Ligonier Township Reservoir) is classified as a "High" hazard - "Small" size dam. The dam and reservoir, owned by the Ligonier Township Municipal Water Authority, are used for water supply. The dam was found to be in good overall condition at the time of inspection.

Hydraulic/hydrologic evaluations, performed in accordance with procedures established by the Baltimore District, Corps of Engineers, for Phase I Inspection Reports, revealed that the spillway will pass approximately 35 percent of the Probable Maximum Flood (PMF) before overtopping will occur. A spillway design flood (SDF) in the range of the 1/2 Probable Maximum Flood (1/2 PMF) to the PMF is required for Ligonier Dam. Because of the relative small size of the impoundment the 1/2 PMF was chosen as the SDF. It was determined that during the 1/2 PMF the low area on the embankment would be overtopped by a depth of 0.66 foot and a duration of 4.50 hours. Because a limiting criteria of one foot or greater depth of overtopping and a duration of 2 hours was estimated for this dam, it was concluded that a dam failure during the 1/2 PMF is unlikely to occur. Therefore, the spillway is considered "inadequate" but not "seriously inadequate." It is recommended that the owner immediately initiate an engineering study to further evaluate the spillway capacity and develop recommendations for remedial measures to reduce the overtopping potential of the dam.

The inspection and review of information revealed certain items of work which should be performed without delay by the owner. These include:

- 1) The owner should immediately initiate an engineering study to further evaluate the spillway capacity in order to develop recommendations for remedial measures to reduce the overtopping potential of the dam.
- 2) The owner should initiate an engineering study to determine if a significant portion of the corrugated metal pipe outlet conduit was left unencased during construction. This study should develop

LIGONIER DAM

recommendations for remedial work, as necessary, and develop recommendations for the repair of the corroded section of pipe and the void under the pipe.

- 3) It is recommended that the dam be raised to the original design elevation of 1674.5 feet Mean Sea Level (M.S.L.).
- 4) The seepage area previously noted should continue to be examined in the future and the condition recorded. Should future inspections disclose that the quantity or encroachment on the downstream face has increased and/or turbidity is observed in the seepage, then further evaluations and corrective measures may become necessary to protect the structural stability of the embankment.

In addition, the following operational measures are recommended to be undertaken by the owner:

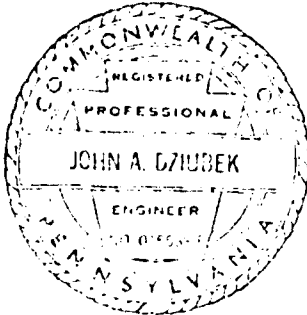
- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

Although the maintenance of Ligonier Dam is genuinely considered to be adequate, it is a good practice that written records and procedures be available for review if it should become necessary. Therefore, it is recommended that formal inspection, maintenance, and operation procedures and records be developed and implemented.

LIGONIER DAM

Submitted by:

MICHAEL BAKER, JR., INC.



John A. Dziubek
John A. Dziubek, P.E.
Engineering Manager-Geotechnical

Date: 27 March 1980

Approved by:

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, CORPS OF ENGINEERS

James W. Peck
JAMES W. PECK
Colonel, Corps of Engineers
District Engineer

Date: 29 April 1980

LIGONIER DAM



Overall View of the Dam from the Right Abutment



Overall View of the Dam from the Left Abutment

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PHASE I INSPECTION REPORT
NATIONAL DAM INSPECTION PROGRAM
LIGONIER DAM
NDI No. PA 00477, PennDER No. 65-117

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

- a. Authority - The Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of inspection of dams throughout the United States.
- b. Purpose of Inspection - The purpose of the inspection is to determine if the dam constitutes a hazard to human life or property.

1.2 DESCRIPTION OF PROJECT

- a. Description of Dam and Appurtenances - Ligonier Dam is an earthfill embankment 510 feet long and a maximum of 35.1 feet high. The embankment has a crest width of 11 feet and side slopes of 3H:1V (Horizontal to Vertical) upstream and 2H:1V downstream. The upstream face of the embankment is protected by hand-placed riprap 12 inches in diameter. A cut-off trench extends the entire length of the embankment. It has a bottom width of 10 feet, 1H:1V side slopes, and a depth of approximately 5 feet or to a satisfactory foundation.

The spillway, located at the right abutment, consists of a sharp-crested, triangular concrete weir. The weir is 60 feet long perpendicular to the flow and 1.5 feet high. The spillway training walls extend approximately 4.8 feet above the crest of the weir. A rectangular reinforced concrete discharge chute extends 30 feet beyond the weir. A channel consisting of riprap grouted in place extends from the discharge chute to the toe of the embankment.

The outlet works for the dam consist of a 12 inch service line and a 30 inch blow-off pipe. Because of post-construction revisions to the intake tower, a 12 inch pipe was installed to discharge into the 30 inch corrugated metal pipe. Both 12 inch lines are operated by gate valves located on the intake tower in the reservoir. The two pipes (12 inch water supply and 30 inch blow-off)

are shown on the drawings as being encased in concrete and having five anti-seep collars.

- b. Location - Ligonier Dam is located on the South Fork of Mill Creek, approximately 1.7 miles southeast of Waterford, Pennsylvania. The structure is located in Ligonier Township, Pennsylvania. The coordinates of the dam are N 40° 14.2' and W 79° 8.8'.
- c. Size Classification - The maximum height of the dam is 35.1 feet. Storage at the top of the dam (Elevation 1673.1 feet Mean Sea Level [M.S.L.]) is 64.4 acre-feet. The dam is therefore on the "Small" size category.
- d. Hazard Classification - Loss of life is likely to result from failure of the dam as there are several residential structures and the Ligonier Township Municipal Water Authority's pump and chlorination building located immediately downstream of the dam. Economic damage to these structures as well as to a secondary road is also likely to occur. Because of this possible property damage and loss of life, Ligonier Dam is classified as a "High" hazard dam.
- e. Ownership - The dam is owned and operated by the Ligonier Township Municipal Water Authority, Box 176, Ligonier, Pennsylvania 15658. Mr. Leonard Hoffer is the current Manager of the water authority.
- f. Purpose of Dam - The impoundment created by the dam serves as a water supply source for the Ligonier Township Municipal Water Authority.
- g. Design and Construction History - Ligonier Dam was designed by the Neilan Engineers of Somerset, Pennsylvania in the spring of 1952. The dam was constructed by Stemmler, Warren and Warren Contractors of Irwin, Pennsylvania. Construction began on 1 July 1953 and was completed on 20 April 1954.
- h. Normal Operational Procedures - The reservoir is typically maintained at the spillway crest elevation (Elevation 1669.7 feet M.S.L.). The operators of the dam make weekly inspections of the embankment. The emergency gate is operated four times a year and the water supply line valve is operated once or twice a year.

1.3 PERTINENT DATA

a.	<u>Drainage Area (square miles)</u> -	2.46
b.	<u>Discharge at Dam Site (c.f.s.)</u> -	
	Maximum Flood -	Unknown
	Spillway Capacity at Maximum Pool (El. 1673.1 ft.) -	1410
c.	<u>Elevation (feet above M.S.L.)</u> -	
	Design Top of Dam -	1674.5
	Minimum Top of Dam -	1673.1
	Average Top of Dam -	1673.6
	Maximum Design Pool -	Unknown
	Spillway Crest -	1669.7
	Streambed at Toe of Dam -	1638
	Maximum Tailwater of Record -	Unknown
d.	<u>Reservoir (feet)</u> -	
	Length of Maximum Pool -	640
	Length of Normal Pool -	580
e.	<u>Storage (acre-feet)</u> -	
	Top of Dam (El. 1673.1 ft.) -	64.4
	Normal Pool (El. 1669.7 ft.) -	45.4
f.	<u>Reservoir Surface (acres)</u> -	
	Top of Dam (El. 1673.1 ft.) -	5.7
	Normal Pool (El. 1669.7 ft.) -	5.2
g.	<u>Dam</u> -	
	Type -	Earthfill
	Total Length (feet) -	510
	Maximum Height (feet) - Design -	36.5
	Field -	35.1
	Top Width (feet) -	11
	Side Slopes - Upstream -	3H:1V
	Downstream -	2H:1V
	Zoning - The design plans show that the embankment is zoned with a central impervious clay core. The upstream section of embankment is "semi- pervious fill" and the downstream embankment is "pervious fill."	
	Impervious Core -	Compacted clay

Cut-off - A clay filled cut-off trench extends the length of the embankment. The trench was excavated to a depth of 5 feet below the existing grade or to a suitable foundation. The bottom of the trench is 10 feet wide and the side slopes are 1H:1V.

Drains - None

h. Diversion and Regulating Tunnel - None

i. Spillway -

Type - Sharp crested, triangular weir

Location - Approximately 35 feet from the right abutment

Length of Crest Perpendicular

to Flow (feet) - 60

Crest Elevation (feet M.S.L.) - 1669.7

Gates - None

Downstream Channel - A rectangular reinforced concrete chute extends 30 feet beyond the crest of the weir. Riprap grouted in place extends from the end of the concrete paving to the toe of the embankment.

j. Outlet Works - The outlet works consist of a 30 inch corrugated metal pipe outlet and a 12 inch source line. The 12 inch water supply line is controlled by a gate valve in the tower. The original 30 inch sluice gate for the outlet pipe is non-functional because of blockage by a steel plate shoring the bottom portion of the intake tower. A 12 inch intake pipe and gate valve was installed at that time to discharge into the 30 inch corrugated metal pipe. The installation consisted of the 12 inch pipe welded to the steel plate and the 30 inch sluice gate being partially opened to allow flow into the 12 inch pipe.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

The information received consisted of Pennsylvania Department of Environmental Resources' (PennDER) File No. 65-117. This file contained a copy of the Neilan Engineers' design plans for the dam and the following information:

- 1) The application made by Ligonier Township Municipal Water Authority to the Water and Power Resources Board for construction of Ligonier Dam (dated 5 May 1952).
- 2) The permit issued by the Water Power Resources Board allowing the Ligonier Township Municipal Water Authority to construct the dam (dated 16 May 1952).
- 3) The Neilan Engineers' specifications for the construction of the dam.
- 4) Various memorandums regarding the construction progress of the dam. Several photos taken by the Water and Power Resources Board during construction were also enclosed.
- 5) Post construction inspection reports, the latest dated 15 June 1971, filed by PennDER, Division of Dams and Encroachments. Other than brush and trees growing on the dam, no serious problems were reported during any of the inspections.

2.2 CONSTRUCTION

During the construction, periodic inspections were made by an engineer representing the Neilan Engineers. Personnel from the Water and Power Resources Board also made several inspections of the dam while construction was in progress.

No "as built" plans were available for review. It appears that several minor changes from the design plans were made during and after construction. These alterations include the following:

- 1) The normal pool surface area of the reservoir was originally proposed to be 3.85 acres. Currently, this area is approximately 5.20

acres. This increase in pond area is probably a result of additional excavation performed in the reservoir area immediately upstream of the spillway. Original site plans indicate that the high ground in this area would be left undisturbed. This area was either regraded to increase the volume of the impoundment or the material there was used as fill for the embankment.

- 2) The average top of dam elevation, as surveyed during the field inspection, is approximately 1673.8 feet M.S.L. Design plans indicate that the top of dam elevation was intended to be 1674.5 feet M.S.L. Only the right 50 feet of the embankment is currently at the design elevation. It was noted in one of the progress reports that the placement of topsoiling and seeding the embankment was deleted from the contractor's work. These items were to be completed by the authority. It is doubtful that the topsoil was placed.
- 3) A portion of the outlet conduit was not encased in concrete. It is not known whether this is true for the entire length.
- 4) It appears the upstream slope was constructed on approximately a 3H:1V slope rather than 2.5H:1V.
- 5) The drawdown facilities were revised in 1972. A 12 inch pipe was installed from the 30 inch sluice gate to discharge into the 30 inch corrugated metal outlet pipe. A steel plate was placed against the wall with the pipe extending through it and the sluice gate was partially opened to allow flow into the pipe.

2.3 OPERATION

The Ligonier Township Municipal Water Authority is responsible for all operations and maintenance.

2.4 EVALUATION

- a. Availability - The information used is readily available from PennDER's File No. 65-117.
- b. Adequacy - The information available is adequate for a Phase I Inspection of this dam.

- c. Validity - There is no reason at the present time to doubt the validity of the available engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

- a. General - The inspection was performed on 11 December 1979. No unusual weather conditions were experienced and the lake was at normal pool. The dam and appurtenant structures were found to be in good overall condition. Noteworthy deficiencies observed during the visual inspection are described in the following paragraphs. The complete visual inspection check list, field sketch, top of dam profile, and typical cross-section are presented in Appendix A.
- b. Dam - The following is a list of obvious deficiencies noted during the visual inspection of the embankment.
 - 1) A small amount (volume less than 1 g.p.m.) of seepage was noted along the toe of the downstream slope approximately 30 feet to the left of the outlet structure. This area was noticed previously by the owner's personnel and engineers from the owner's engineering company (Neilan Engineers) came out to the dam site to examine the seepage area. According to the owner's personnel it was reported that the area was the result of underseepage from the rock joints (fractures). This area is examined by the owner's personnel approximately 4 times a month. No migration of fine material was observed at the time of the Phase I Inspection.
 - 2) Other areas of local moist spots were observed along the toe of the embankment. No discernible flow was coming from these areas at the time of inspection. The entire area downstream of the left side of the embankment was marshy and water was ponded in some areas.
 - 3) The crest of the embankment was low (see top of dam profile at the end of Appendix A). The top of dam should be raised to design elevation of 1674.5 feet M.S.L.
 - 4) Minor erosion channels were present on the downstream face; however, these are not severe enough to require attention at this time.

c. Appurtenant Structures - The few minor deficiencies observed are as follows:

- 1) The invert of the 30 inch corrugated metal pipe has rusted out for a section extending from 12.5 feet from the endwall to a point 23 feet from the endwall. A void approximately 8 inches deep has formed below this section of pipe. This raises a question as to how much of the outlet conduit was encased in concrete as shown on the design drawings.
- 2) A heavy coat of rust has formed on the piping in the inlet tower.
- 3) The addition of a steel plate for shoring in the outlet tower has made the original 30 inch (estimated) sluice gate inoperable. However, this gate has been replaced by a 12 inch intake and gate valve.

No deficiencies or items of repair work were observed for the spillway structure. This structure appeared to be in good condition.

d. Reservoir Area - The slopes of the reservoir and drainage basin are moderate to steep. A majority of the watershed is forested with some small farms. A relatively minor amount of sediment has accumulated in the reservoir. The owner's personnel at the dam stated that a diver inspecting the outlet works in 1970 reported that the sediment level at the outlet works was approximately 2 feet deep.

e. Downstream Channel - A small log bridge providing access to the chlorination building crosses the channel approximately 200 feet downstream of the dam. Four residential structures are located approximately 3900 feet downstream from the dam within the floodplain of the South Fork of Mill Creek. In addition, a large number (estimated over 100) of homes are located within the floodplain of Mill Creek in Waterford, Pennsylvania.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

There are no formal procedures for operating the reservoir or evacuating the downstream area in case of an impending failure of the dam. It is recommended that formal emergency procedures be adopted, prominently displayed, and furnished to all operating personnel.

4.2 MAINTENANCE OF DAM

The Ligonier Township Municipal Water Authority is responsible for the maintenance of the dam. Generally, the maintenance procedures followed are considered adequate; however, a more conscientious program to record for future reference the maintenance performed would be desirable.

4.3 MAINTENANCE OF OPERATING FACILITIES

The 12 inch gate valve which can be used for emergency drawdown is operated four times a year and the 12 inch gate valve for the water supply line is tested twice yearly. Maintenance is performed on an as needed basis. It is recommended that a formal operation and preventive maintenance schedule be developed and implemented.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no warning system in the event of a dam failure. An emergency warning system should be developed.

4.5 EVALUATION OF OPERATIONAL ADEQUACY

The current operational features are adequate for the purpose they serve.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

- a. Design Data - There is no detailed hydraulic or hydrologic design information available for Ligonier Dam. However, in the PennDER file on this dam, both the permit application and the proposed design plans for the dam indicate that the spillway was intended to have a freeboard of 4.8 feet. Using this freeboard and a discharge coefficient of 3.75, it was stated in the permit application that the spillway capacity would be 2360 c.f.s.
- b. Experience Data - No rainfall or maximum pool records are available.
- c. Visual Observation - There are two low spots on the crest of the dam, one at Station 1+00 and the second at Station 2+00. These areas are approximately 3.4 feet above the spillway crest elevation. The entire left abutment (Station 0+10 to 4+20) is below the elevation required for the spillway to have 4.8 feet of freeboard.
- d. Overtopping Analysis - Ligonier Dam is a "Small" size - "High" hazard dam requiring evaluation for a spillway design flood (SDF) in the range of the 1/2 Probable Maximum Flood (1/2 PMF) to the Probable Maximum Flood (PMF). Due to the relatively small size of the impoundment created by the dam, the 1/2 PMF event was selected as the SDF for Ligonier Dam.

The hydraulic capacity of the dam, reservoir, and spillway was assessed by utilizing the U.S. Army Corps of Engineers' Flood Hydrograph Package, HEC-1 DB. The hydrologic characteristics of the drainage basin, specifically, the Snyder's unit hydrograph parameters, were obtained from a regionalized analysis conducted by the Baltimore District of the U.S. Army Corps of Engineers.

Analysis of the dam and spillway show that the dam would be overtopped for 4.50 hours by a maximum of 0.66 foot during the 1/2 PMF event. The spillway is capable of passing approximately 35 percent of the PMF before overtopping begins.

Additional Phase I analysis of the dam, including an HEC-1 DB run, indicated that if the low areas on the crest were raised to Elevation 1674.0

feet M.S.L., the dam would not be overtopped by the 1/2 PMF.

- e. Spillway Adequacy - As outlined in the above analysis, the dam would be overtopped by the SDF. The next criteria for spillway adequacy determination requires an estimate of whether the dam will fail during the 1/2 PMF. The following conditions, as well as the overall state of the dam, were used as the limiting criteria which are likely to cause failure of the dam.

- 1) Depth of overtopping of 1.0 foot or greater.
- 2) Duration of overtopping in excess of 2 hours.

The overtopping analyses of this dam yielded the following values for the 1/2 PMF.

- 1) Depth of overtopping equal to 0.66 foot.
- 2) Duration of overtopping equal to 4.50 hours.

As a result of these analyses, the spillway is rated as "inadequate" but not "seriously inadequate".

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

- a. Visual Observations - The seepage observed to the right of the outlet structure is considered minor at this time. However, the owner's personnel and the owner's engineer should continue to visually examine the area in future inspections and record the condition. Should the quantity of seepage increase significantly, or migration of fines observed, or the seepage begin to exit from the downstream face; then additional evaluations and corrective measures may become necessary. The other additional areas along the toe should also be visually examined and the condition recorded.

No evidence of distress was observed for the embankment or appurtenant structures. The absence of the concrete encasement for a portion of the outlet conduit leaves a serious question as to how much of the outlet conduit was actually encased. The design plans indicate only the last 10 feet of the outlet conduit was to be left unencased; however, the area where the pipe rusted through and a void observed beneath the pipe was upstream of the last 10 foot section. It is recommended that the owner's engineer further investigate the possibility that a significant portion of the outlet conduit was left unencased. The owner's engineer should develop recommendations for the repair of the outlet conduit where it is rusted through, and in the event that portions of the outlet conduit was left unencased, recommendations for the revisions necessary to the outlet conduit should be developed and implemented.

- b. Design and Construction Data - Calculations of the structural stability were not available for review. No information concerning the dam foundation materials or conditions were available. It is estimated for this dam, with its history of satisfactory performance of the slopes and the fact that no instability was observed during the field inspection, that further assessments of the stability are not necessary for this Phase I Inspection Report. As noted in paragraph 6.1.a., should future inspections observe signs of distress or conditions which would affect the structural stability of the embankment, additional evaluations and corrective measures may become necessary.

- c. Operating Records - Nothing in the operational information indicates concern relative to the structural stability of the dam.
- d. Post-Construction Changes - None of the post-construction changes previously noted in this report adversely affect the structural stability of the dam.
- e. Seismic Stability - The dam is located in Seismic Zone 1 of the "Seismic Zone Map of the Contiguous United States," Figure 1, page D-30, "Recommended Guidelines for Safety Inspection of Dams." This is a zone of minor seismic activity. Therefore, further consideration of the seismic stability is not warranted.

SECTION 7 - ASSESSMENT, RECOMMENDATION/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

- a. Safety - Ligonier Dam was found to be in good overall condition. The dam is a "High" hazard - "Small" size dam requiring a spillway capacity in the range of the 1/2 PMF to PMF. The 1/2 PMF was chosen as the SDF because of the relatively small size of the impoundment. As presented in Section 5, the spillway and reservoir are capable of passing 35 percent of the PMF before overtopping will occur. During the 1/2 PMF, the depth and duration of overtopping are 0.66 foot and 4.50 hours, respectively. Because a limiting criteria of one foot or greater depth of overtopping and a duration of 2 hours was estimated for this dam, it was concluded that a dam failure during the 1/2 PMF is unlikely to occur. Therefore, the spillway is considered "inadequate" but not "seriously inadequate".

Further, if the low areas on the top of the dam are raised to Elevation 1674.0 feet M.S.L. (0.5 foot below original design top of dam) then the dam would not be overtopped by the 1/2 PMF.

The seepage observed is considered minor but should continue to be visually examined in the future. If the conditions change then additional evaluations and corrective measures may become necessary.

The absence of the concrete encasement for a portion of the corrugated metal pipe outlet conduit indicates concern for other more critical sections of the pipe upstream from the observed portion. It is recommended that an evaluation of the extent of the actual construction of the concrete encasement be performed and recommendations developed for remedial work.

- b. Adequacy of Information - The information available and the observations made during the visual inspection are considered sufficient for this Phase I Inspection Report.
- c. Urgency - The owner should initiate the action discussed in paragraph 7.2 without delay and immediately initiate the additional evaluation indicated in paragraph 7.1.d.

4. Necessity for Additional Data/Evaluation - The hydraulic/hydrologic analyses performed for this dam has indicated the need for additional spillway capacity. Therefore, the owner should retain the services of a qualified professional engineer experienced in the design and construction of earth dams to further evaluate the spillway capacity and develop recommendations to reduce the overtopping potential of the dam.

The owner should initiate an engineering study to determine if a significant portion of the corrugated metal pipe outlet conduit was left unencased during construction and to develop recommendations for remedial work as necessary.

7.2 RECOMMENDATIONS/REMEDIAL MEASURES

The inspection and review of information revealed certain items of work which should be performed without delay by the owner. These include:

- 1) The owner should immediately initiate an engineering study to further evaluate the spillway capacity in order to develop recommendations for remedial measures to reduce the overtopping potential of the dam.
- 2) The owner should initiate an engineering study to determine if a significant portion of the corrugated metal pipe outlet conduit was left unencased during construction. This study should develop recommendations for remedial work as necessary and develop recommendations for the repair of the corroded section of pipe and the void under the pipe.
- 3) It is recommended that the dam be raised to the original design elevation of 1674.5 feet M.S.L.
- 4) The seepage area previously noted should continue to be examined in the future and the condition recorded. Should future inspections disclose that the quantity or encroachment on the downstream face has increased and/or turbidity is observed in the seepage, then further evaluations and corrective measures may become necessary to protect the structural stability of the embankment.

In addition, the following operational measures are recommended to be undertaken by the owner:

- 1) Develop a detailed emergency operation and warning system.
- 2) During periods of unusually heavy rain, provide around-the-clock surveillance of the dam.
- 3) When warning of a storm of major proportions is given by the National Weather Service, the owner should activate the emergency operation and warning system.

Although the maintenance of Ligonier Dam is genuinely considered to be adequate, it is a good practice that written records and procedures be available for review if it should become necessary. Therefore, it is recommended that formal inspection, maintenance, and operation procedures and records be developed and implemented.

APPENDIX A

VISUAL INSPECTION CHECK LIST, FIELD SKETCH,
TOP OF DAM PROFILE, AND TYPICAL CROSS-SECTION

A-1

Check List
Visual Inspection
Phase 1

Name of Dam Ligonier Dam County Westmoreland State PA Coordinates Lat. N 40°14.2'
NDI # PA 00477 Long. W 79°8.8'
PennDER # 65-117
Date of Inspection 11 December 1979 Weather Cool, sunny Temperature 40°-50° F.

Pool Elevation at Time of Inspection 1669.9 ft. M.S.L.* Tailwater at Time of Inspection 1630.0 ft. M.S.L.*

*All elevations referenced to the spillway crest (El. 1669.7 ft.)

Inspection Personnel:

Michael Baker, Jr., Inc.:

James G. Ulinski
Wayne D. Lasch
Jeffrey S. Maze

Field Review (18 March 1980)

John A. Dziubek
James G. Ulinski

Owner's Representatives:

Mr. Leonard Hoffer
Mr. Liberty Maggie

James G. Ulinski Recorder

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
LEAKAGE		
STRUCTURE TO ABUTMENT/EMBANKMENT JUNCTIONS		
DRAINS		
WATER PASSAGES		
FOUNDATION		

CONCRETE/MASONRY DAMS - Not Applicable

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS CONCRETE SURFACES		
STRUCTURAL CRACKING		
VERTICAL AND HORIZONTAL ALIGNMENT		
MONOLITH JOINTS		
CONSTRUCTION JOINTS		

EMBANKMENT

Name of Dam LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
SURFACE CRACKS	None observed	

UNUSUAL MOVEMENT OR
 CRACKING AT OR BEYOND
 THE TOE

None observed

SLOUGHING OR EROSION OF
 EMBANKMENT AND ABUTMENT
 SLOPES

Some minor erosion channels are
 present on the downstream face
 but none of these are sufficiently
 deep to require repair at this time.

Visually observe in future
 inspections and correct when
 necessary.

EMBANKMENT

Name of Dam LIGONIER DAM
NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
VERTICAL AND HORIZONTAL ALIGNMENT OF THE CREST	Visual inspection of the horizontal alignment indicated no problems. The top of dam profile (Appendix D) shows that the left section of the embankment is low. Elevations of the dam crest range from 1674.5 ft. M.S.L. on the right side of the embankment to a minimum of 1673.1 ft. M.S.L. at Station 1+00.	The top of dam elevation should be restored to the original design Elevation of 1674.5 ft. M.S.L.

RIPRAP FAILURES

None, the riprap is hand-placed and in good condition.

EMBANKMENT

Name of Dam LIGONIER DAMNDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
JUNCTION OF EMBANKMENT AND ABUTMENT, SPILLWAY AND DAM	No distress observed. The left abutment junction is low and should be raised.	
ANY NOTICEABLE SEEPAGE	A very small amount (Q < 1 g.p.m.) of seepage was observed approximately 30 ft. left of the outlet along the downstream toe. This area has been observed by the owner's engineer (Neilan Engineers) and according to the owner's personnel was reported as underseepage through the rock joints (fractures). This area is visually examined by the owner's personnel approx- imately 4 times a month. Other local moist spots were observed along the toe of the embankment and the entire area on the left downstream side is marshy. Part of the marshy area is the result of a small creek and spring from the left downstream hillside.	Continue to visually monitor these areas and record the condition. Should the amount of seepage increase, begin to carry fine soil particles, or start to exit from the down- stream face of the embankment, then additional elevation and corrective measures may become necessary.
STAFF GAGE AND RECORDER	None	
DRAINS	None observed for the embankment. Two sets of drains on 5 ft. spacings from under the spillway structure are in reasonable condi- tion. Weepholes in spillway training walls are in good condition.	

OUTLET WORKS

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CRACKING AND SPALLING OF CONCRETE SURFACES IN OUTLET CONDUIT	Outlet conduit consists of a 30 in. C.M.P. The invert of the pipe is rusted out with a void approximately 8 in. deep below it. The void started 23 ft. upstream of the end of the pipe and went to 12.5 ft. upstream from the end of the pipe.	Either replace the pipe or grout and line the 30 in. C.M.P.
INTAKE STRUCTURE	Intake structure appeared in good con- dition. However, a heavy coating of rust has developed on the piping in the tower. One of the 12 in. gate valves and the 30 in. sluice gate are inoperable.	
OUTLET STRUCTURE	No problems observed other than reported for the outlet conduit.	
OUTLET CHANNEL	No problems observed	
EMERGENCY GATE	The original 30 in. sluice gate was replaced with a 12 in. gate valve and pipe which is operated four times a year. There is a 12 in. gate valve for the water supply line which is operated twice a year.	

UNGATED SPILLWAY

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONCRETE WEIR	Sharp crested, triangular weir in good condition.	
APPROACH CHANNEL	No problems observed	
DISCHARGE CHANNEL	No problems were observed. The riprap was grouted in place with concrete by the owner several years ago.	
BRIDGE AND PIERS	None	

GATED SPILLWAY - Not Applicable

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

CONCRETE SILL

APPROACH CHANNEL

DISCHARGE CHANNEL

BRIDGE AND PIERS

GATES AND OPERATION
EQUIPMENT

INSTRUMENTATION - None

Name of Dam: LIGONIER DAM
NDI # PA 00477

VISUAL EXAMINATION	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
--------------------	--------------	----------------------------

MONUMENTATION/SURVEYS

OBSERVATION WELLS

WEIRS

PIEZOMETERS

OTHER

RESERVOIR

Name of Dam: LIGONIER DAM
NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
-----------------------	--------------	----------------------------

SLOPES	Slopes are moderate to steep with forest on most of the drainage area except for a small farm.	
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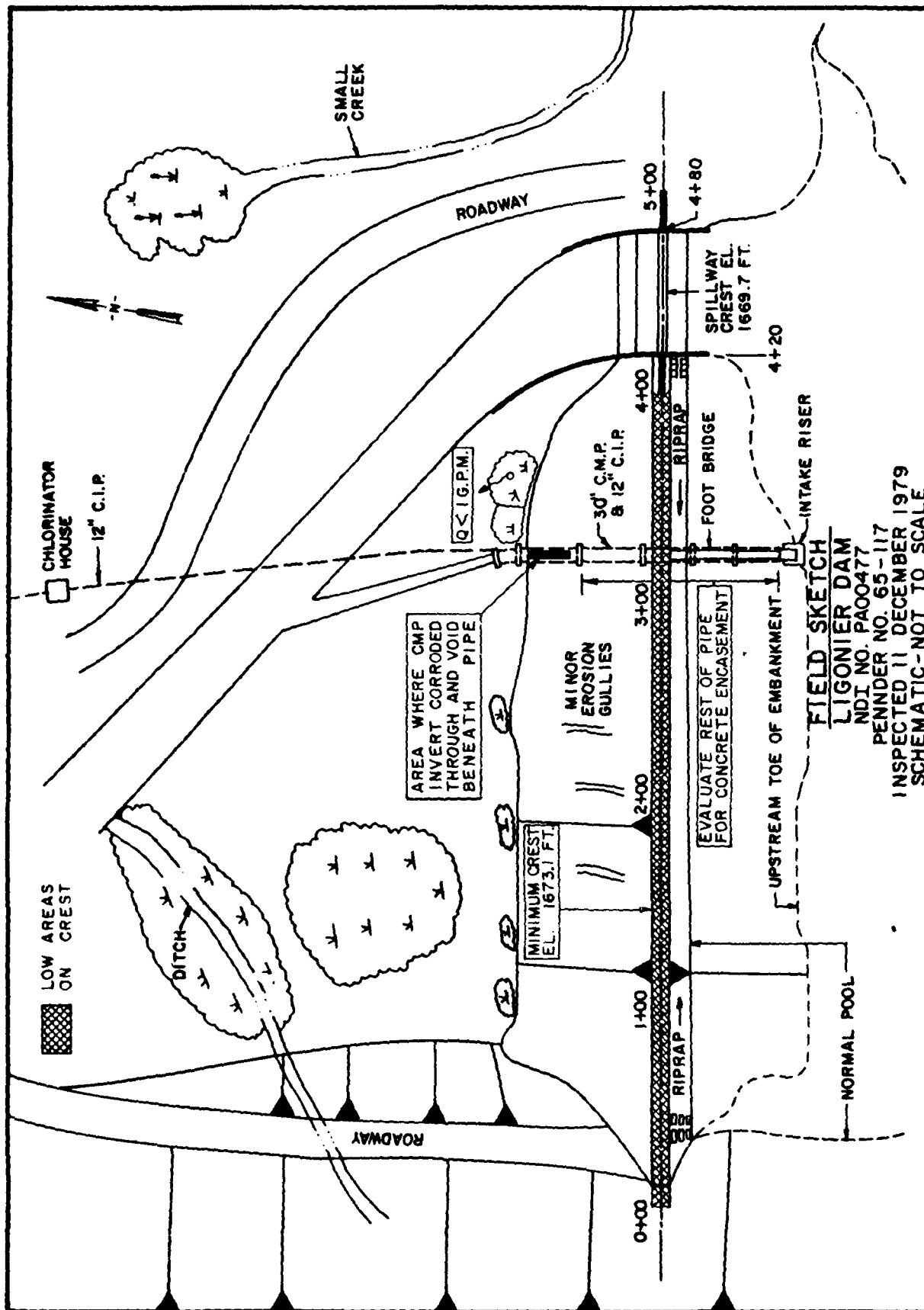
SEDIMENTATION

In 1972 a diver inspected the condition of the intake structure and reported there was approximately 2 ft. of sediment in the lower areas of the reservoir.

DOWNSTREAM CHANNEL

Name of Dam: LIGONIER DAM
 NDI # PA 00477

VISUAL EXAMINATION OF	OBSERVATIONS	REMARKS OR RECOMMENDATIONS
CONDITION (OBSTRUCTIONS, DEBRIS, ETC.)	A small bridge is located approximately 200 ft. downstream of dam. This bridge would not severely restrict flow as it would easily be overtopped.	
SLOPES	The slopes of the downstream area are gentle to moderate.	
APPROXIMATE NO. OF HOMES AND POPULATION	A small log bridge providing access to the chlorinator building crosses the channel approximately 200 ft. downstream of the dam. Four residential structures are located approximately 3900 ft. downstream from the dam within the floodplain of the South Fork of Mill Creek. In addition a large number (estimated over 100) of homes are located within the floodplain of Mill Creek in Waterford, Pennsylvania.	

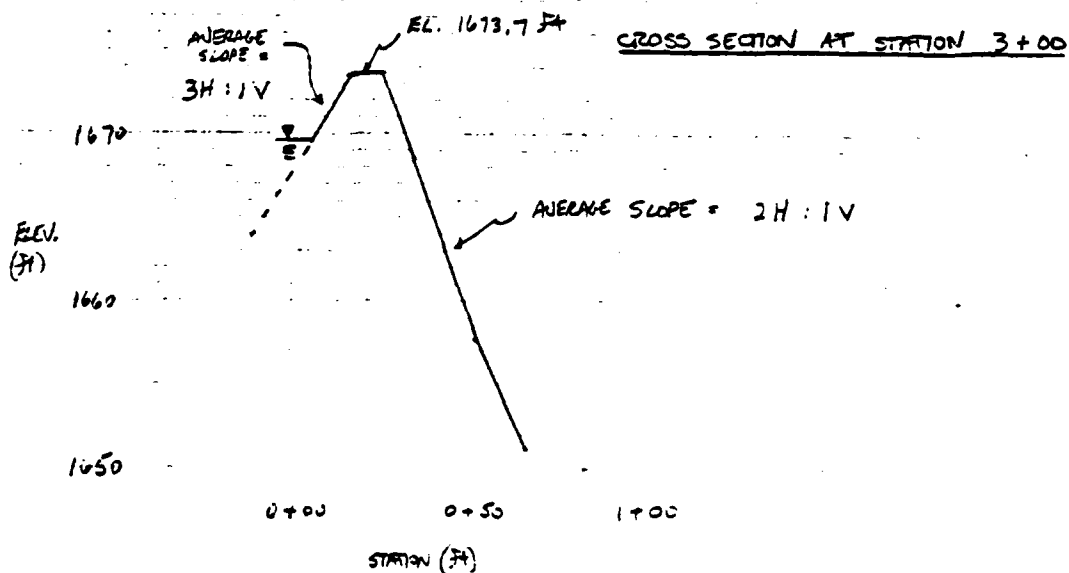
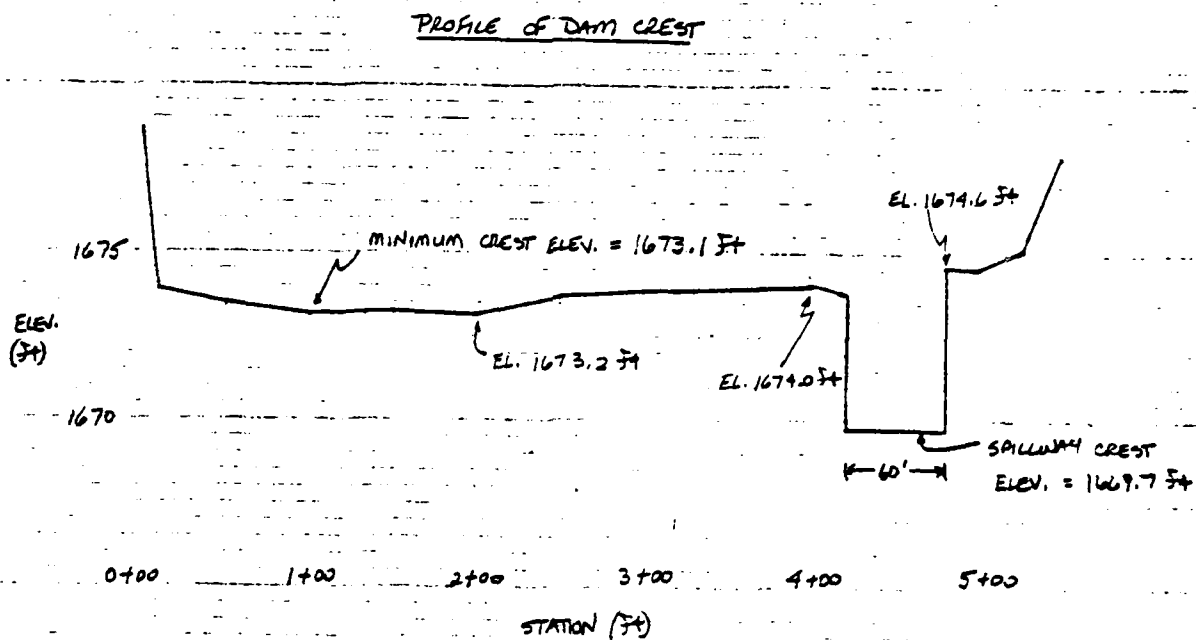


MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS
20 February 1980
Box 280
Beaver, Pa. 15009

LIGONIER DAM
TOP OF DAM PROFILE
TYPICAL CROSS-SECTION

A-14

DATE OF INSPECTION - 11 December 1979



APPENDIX B

ENGINEERING DATA CHECK LIST

CHECK LIST
ENGINEERING DATA
DESIGN, CONSTRUCTION, OPERATION

Name of Dam: LIGONIER DAM
NDI # PA 00477

ITEM	REMARKS
PLAN OF DAM	See Plates 3 and 4 of this report.
REGIONAL VICINITY MAP	See Location Plan (Plate 1) of this report. A USGS 7.5 minute topographic quadrangle, Ligonier, Pennsylvania was used to prepare the Location Plan.
CONSTRUCTION HISTORY	Ligonier Dam was designed by the Neilan Engineers of Somerset, Pennsylvania in the spring of 1952. The dam was constructed by Stemmler, Warren and Warren contractors of Irwin, Pennsylvania. Construction began on 1 July 1953 and was completed on 20 April 1954.
TYPICAL SECTIONS OF DAM	See Plate 7 of this report.
HYDROLOGIC/HYDRAULIC DATA	No information available
OUTLETS - PLAN	See Plates 3 and 4 of this report.
- DETAILS	See Plate 5 of this report.
- CONSTRAINTS	The original 30 in. sluice gate has been replaced by a steel plate used for shoring in the intake tower and a smaller diameter (estimated 12 in.) pipe which discharges into the 30 in. C.M.P.
- DISCHARGE RATINGS	None available
RAINFALL/RESERVOIR RECORDS	Rainfall records are presently kept. The water level remains fairly constant and for that reason is not recorded.

Name of Dam: LIGONIER DAM

NDI # PA 00477

B-2

ITEM	REMARKS
DESIGN REPORTS	None available
GEOLOGY REPORTS	None available, see Appendix F for regional geology.
DESIGN COMPUTATIONS HYDROLOGY & HYDRAULICS DAM STABILITY SEEPAGE STUDIES	None available
MATERIALS INVESTIGATIONS BORING RECORDS LABORATORY FIELD	No information available
POST-CONSTRUCTION SURVEYS OF DAM	No information available
BORROW SOURCES	No information available

Name of Dam: LIGONIER DAM

NDI # PA 00477

B-3

ITEM	REMARKS
------	---------

MONITORING SYSTEMS

None

MODIFICATIONS

Modifications include a new 12 in. gate valve installed in sluice gate chamber and grouted riprap placed in the chute channel.

HIGH POOL RECORDS

No information available

POST-CONSTRUCTION ENGINEERING
STUDIES AND REPORTS

Inspections were performed by PennDER personnel on 22 April 1964 and 15 June 1971. These reports are available in the PennDER file. According to the owner's personnel, the intake tower and gates were inspected by divers in 1972. No formal report was available.

PRIOR ACCIDENTS OR FAILURE OF DAM
DESCRIPTION
REPORTS

None

MAINTENANCE
OPERATION
RECORDS

Embankment vegetation was cut last year. Embankment is walked approximately 4 times a month and the area of previously noted seepage examined. No formal records are maintained.

Name of Dam: LIGONIER DAM

B-4

NDI # PA 00477

ITEM	REMARKS
------	---------

SPILLWAY PLAN,

SECTIONS,
and
DETAILS

See Plate 6 of this report.

OPERATING EQUIPMENT
PLANS & DETAILS

See Plate 5 of this report.

CHECK LIST
HYDROLOGIC AND HYDRAULIC DATA
ENGINEERING DATA

DRAINAGE AREA CHARACTERISTICS: 2.46 sq. mi. (primarily forests with
some farmland)

ELEVATION TOP NORMAL POOL (STORAGE CAPACITY): 1669.7 ft.
(45.4 ac.-ft.)

ELEVATION TOP FLOOD CONTROL POOL (STORAGE CAPACITY): 1673.1 ft.
(69.4 ac.-ft.)

ELEVATION MAXIMUM DESIGN POOL: Unknown

ELEVATION TOP DAM: 1673.1 ft. (minimum elevation)

SPILLWAY: _____

- a. Crest Elevation 1669.7 ft.
- b. Type Concrete, triangular, sharp-crested weir
- c. Width of Crest Parallel to Flow 3.0 ft.
- d. Length of Crest Perpendicular to Flow 60 ft.
- e. Location Spillover Right abutment
- f. Number and Type of Gates None

OUTLET WORKS: _____

- a. Type 12 in. service line and 30 in. blow-off pipe
- b. Location 210 ft. from right abutment
- c. Entrance Inverts 1647.0 ft. (invert of 30 in. from design plans
- d. Exit Inverts 1636.8 ft. (invert of 30 in. blow-off pipe)
- e. Emergency Drawdown Facilities The impoundment can be drawn
down using the 30 in. blow-
off pipe and the 12 in.
service line

HYDROMETEOROLOGICAL GAGES: None

- a. Type _____
- b. Location _____
- c. Records _____

MAXIMUM NON-DAMAGING DISCHARGE No records available

APPENDIX C

PHOTOGRAPH LOCATION PLAN AND PHOTOGRAPHS

DETAILED PHOTOGRAPH DESCRIPTIONS

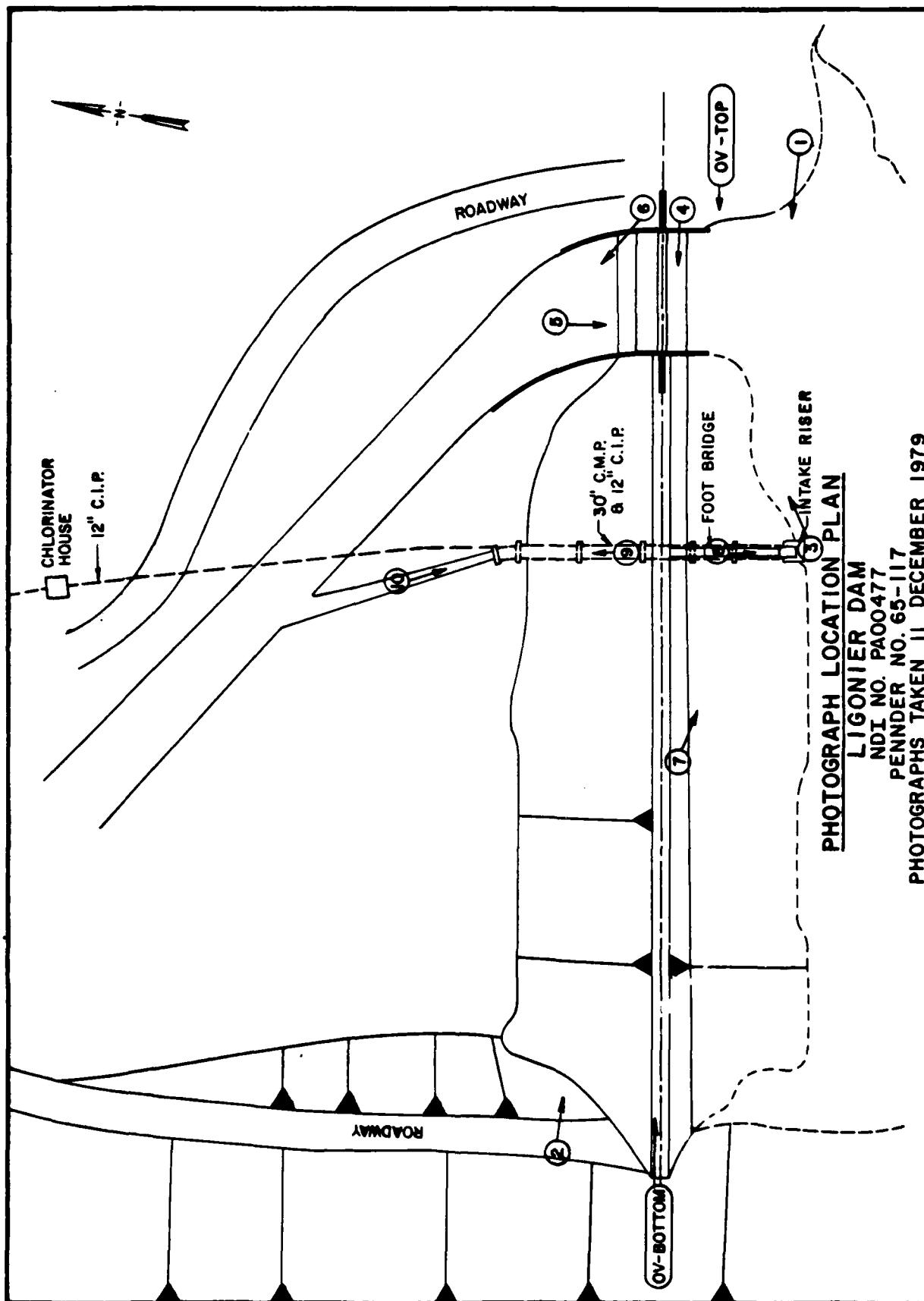
Overall View of Dam

- Top Photo - Overall View of Dam from the Right Abutment
(OV-T)
Bottom Photo - Overall View of Dam from the Left Abutment
(OV-B)

Photograph Location Plan

- Photo 1 - View of the Upstream Slope of the Embankment from the Right Abutment
- Photo 2 - View of the Downstream Slope of the Embankment from the Left Abutment
- Photo 3 - View of the Entrance to the Spillway from the Gate Tower
- Photo 4 - View of the Crest of the Spillway from the Right Abutment
- Photo 5 - View Looking Upstream at the Crest of the Spillway
- Photo 6 - View Looking Downstream at the Spillway Discharge Channel
- Photo 7 - View of the Gate Tower
- Photo 8 - View of the Control Valves on the Gate Tower
- Photo 9 - View of the Outlet Head Wall Location and Discharge Channel from the Crest of the Embankment
- Photo 10 - View Looking Upstream at the Outlet Head Wall

Note: Photographs were taken on 11 December 1979.



PHOTOGRAPH LOCATION PLAN

LIGONIER DAM

NDI NO. PA00477

PENNDER NO. 65-117

PHOTOGRAPHS TAKEN 11 DECEMBER 1979

LIGONIER DAM



PHOTO 1. View of the Upstream Slope of the Embankment
from the Right Abutment



PHOTO 2. View of the Downstream Slope of the Embankment
from the Left Abutment

LIGONIER DAM



PHOTO 3. View of the Entrance to the Spillway from the Gate Tower



PHOTO 4. View of the Crest of the Spillway from the Right Abutment

LIGONIER DAM



PHOTO 5. View Looking Upstream at the Crest of the Spillway



PHOTO 6. View Looking Downstream at the Spillway Discharge Channel

LIGONIER DAM



PHOTO 7. View of the Gate Tower



PHOTO 8. View of the Control Valves on the Gate Tower

LIGONIER DAM



**PHOTO 9. View of Outlet Head Wall Location and Discharge Channel
from the Crest of the Embankment**



PHOTO 10. View Looking Upstream at the Outlet Head Wall

APPENDIX D

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject LIGONIER DAM S.O. No. _____
APPENDIX D - HYDROLOGIC AND Sheet No. _____ of _____
HYDRAULIC ANALYSIS Drawing No. _____
Computed by _____ Checked by _____ Date _____

<u>SUBJECT</u>	<u>PAGE</u>
PREFACE	i
HYDROLOGY AND HYDRAULIC DATA BASE	1
HYDRAULIC DATA	2
DRAINAGE AREA AND CENTROID MAP	3
DAM CREST PROFILE AND CROSS-SECTION	4
SPILLWAY DISCHARGE RATING AND CAPACITY ANALYSIS	5
HEC-1 COMPUTER ANALYSIS	6

PREFACE

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

The hydrologic determinations presented in this Phase I Inspection Report are based on the use of a Snyder's unit hydrograph developed by the U.S. Army Corps of Engineers. Due to the limited number of gaging stations available in this hydrologic region and the wide variations of watershed slopes, the Snyder's coefficients may yield results of limited accuracy for this watershed. As directed however, a further refinement of these coefficients is beyond the scope of this Phase I Investigation.

In addition, the conclusions presented pertain to present conditions, and the effect of future development on the hydrology has not been considered.

HYDROLOGY AND HYDRAULIC ANALYSIS DATA BASE

NAME OF DAM: LIGONIER DAM

PROBABLE MAXIMUM PRECIPITATION (PMP) = 23.9 INCHES/24 HOURS⁽¹⁾

STATION	1	2	3	4	5
Station Description	LIGONIER DAM				
Drainage Area (square miles)	2.46				
Cumulative Drainage Area (square miles)	2.46				
Adjustment of PMF for Drainage Area (%) ⁽²⁾	Zone 7				
6 Hours	102				
12 Hours	120				
24 Hours	130				
48 Hours	140				
72 Hours	-				
Snyder Hydrograph Parameters					
Zone ⁽³⁾	24				
C_p/C_t ⁽⁴⁾	0.45/1.6				
L (miles) ⁽⁵⁾	3.64				
L_{ca} (miles) ⁽⁵⁾	1.70				
$t_p = C_t (L \cdot L_{ca})^{0.3}$ (hours)	2.76				
Spillway Data					
Crest Length (ft)	60.0				
Freeboard (ft)	3.4				
Discharge Coefficient	3.75				
Exponent	1.5				

⁽¹⁾ Hydrometeorological Report 33 (Figure 1), U.S. Army, Corps of Engineers, 1956.

⁽²⁾ Hydrometeorological Report 33 (Figure 2), U.S. Army, Corps of Engineers, 1956.

⁽³⁾ Hydrological zone defined by Corps of Engineers, Baltimore District, for determining Snyder's Coefficients (C_p and C_t).

⁽⁴⁾ Snyder's Coefficients.

⁽⁵⁾ L = Length of longest water course from outlet to basin divide.

L_{ca} = Length of water course from outlet to point opposite the centroid of drainage area.

MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject LIGNIER DAM

HYDRAULIC DATA

S.O. No. _____

Sheet No. 2 of 10

Drawing No. _____

Computed by WDL

Checked by WLS

Date 2-20-30

STORAGE CALCULATIONS :

ELEVATION VS. AREA DATA (MEASURED FROM QUADS)

<u>ELEVATION, FT</u>	<u>AREA, ACRES</u>
1669.7	5.20
1680.0	6.12
1700.0	11.33

NOTE: NORMAL POOL LEVEL ASSUMED
TO BE AT ELEV. 1669.7 FT

STORAGE AT NORMAL POOL :

$$\text{STORAGE} = V_{NP} = \frac{h}{3} (A_1 + A_2 + \sqrt{A_1 A_2})$$

h = AVERAGE DEPTH = 9.0 FT
(ESTIMATED FROM MEASUREMENTS
MADE DURING INSPECTION)

A_1 = AREA OF NORMAL POOL = 5.20 AC

A_2 = AREA OF RESERVOIR BOTTOM
= 4.90 AC

(ESTIMATED FROM DEPTH AND
SURROUNDING GROUND SLOPES)

$$V_{NP} = \frac{9}{3} (5.20 + 4.90 + \sqrt{(5.20)(4.90)})$$

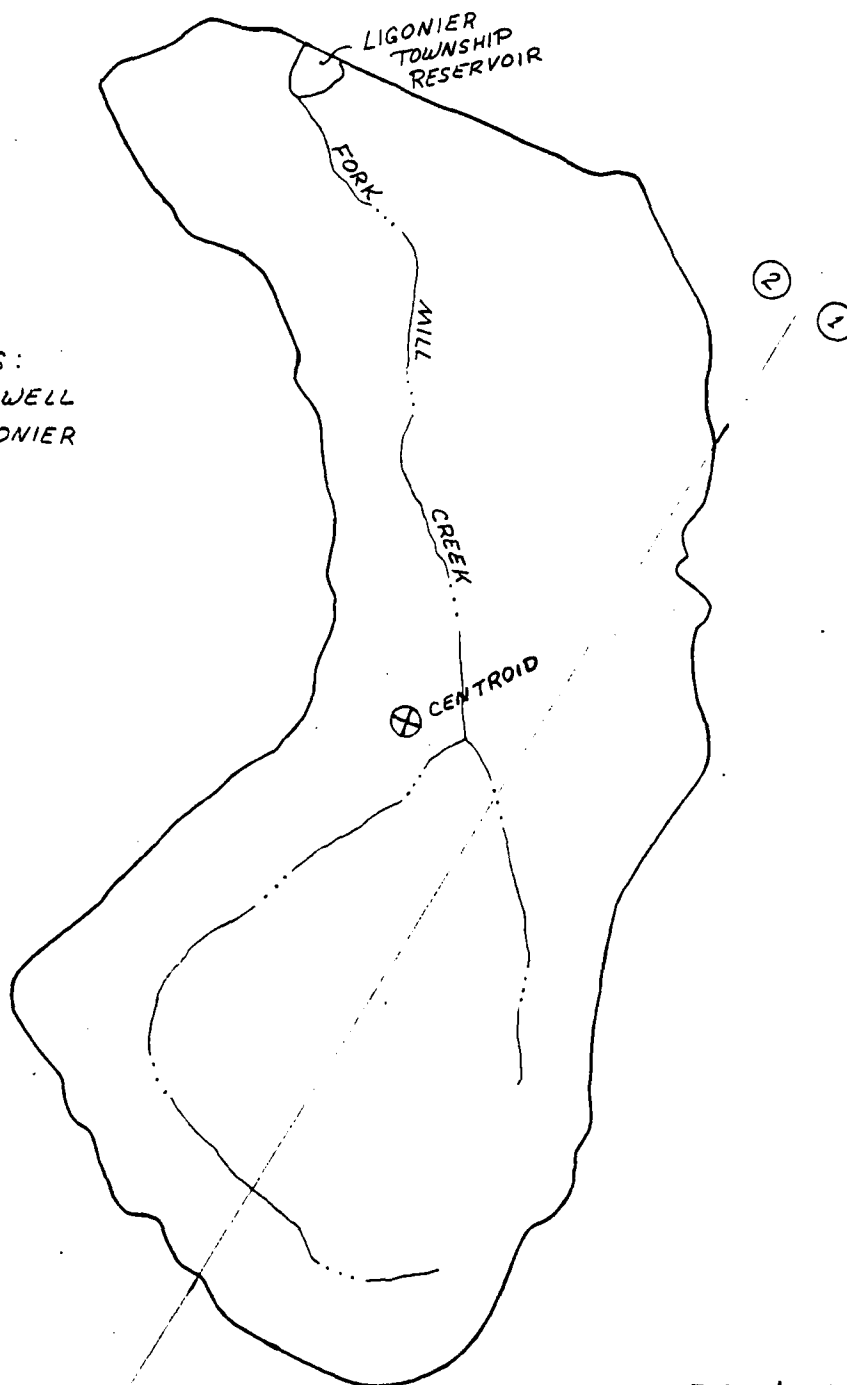
$$V_{NP} = \underline{45.44 \text{ AC-FT}}$$

STORAGE AT TOP OF DAM : (FROM HEC-1 ANALYSIS)

$$\text{STORAGE AT TOP OF DAM} = 64.4 \text{ AC-FT}$$

QUADS:

1. BOSWELL
2. LIGONIER



DRAINAGE AREA AND
CENTROID MAP FOR
LIGONIER DAM

MICHAEL BAKER, JR., INC.

THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject LIGONIER DAM

S.O. No. _____

PROFILE OF DAM CREST

Sheet No. 4 of 10

AND CROSS SECTION

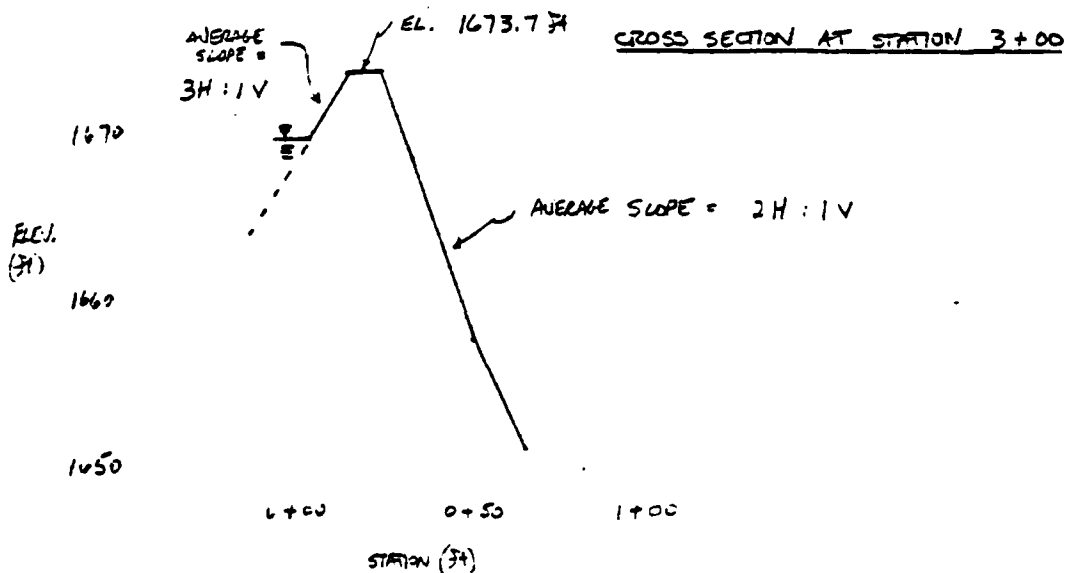
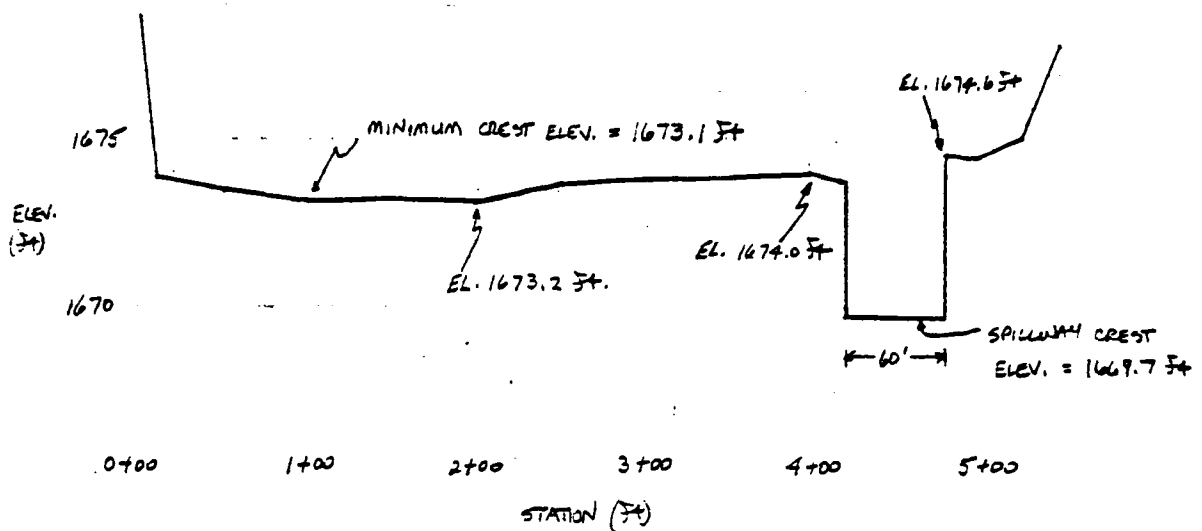
Drawing No. _____

Computed by WLS

Checked by WDL

Date 2-20-30

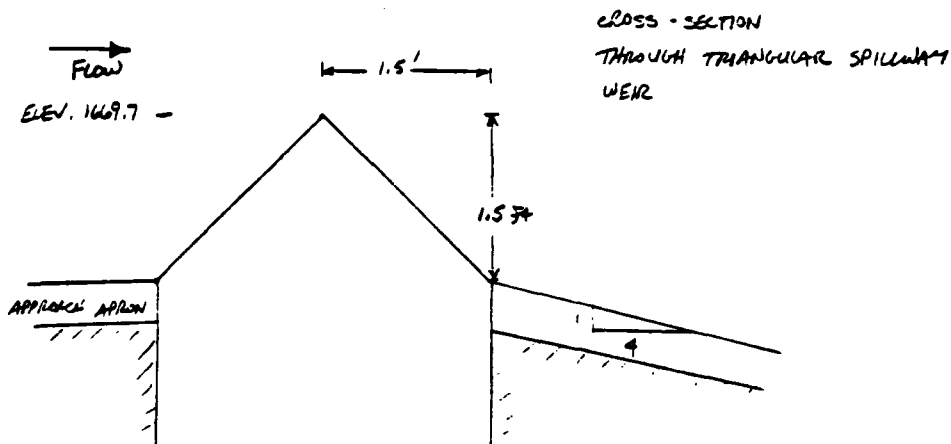
PROFILE OF DAM CREST



MICHAEL BAKER, JR., INC.
THE BAKER ENGINEERS

Box 280
Beaver, Pa. 15009

Subject LIGONIER DAM S.O. No. _____
SPILOWAY DISCHARGE RATING Sheet No. 5 of 10
AND CAPACITY ANALYSIS Drawing No. _____
Computed by WDL Checked by LAD Date 2-20-80



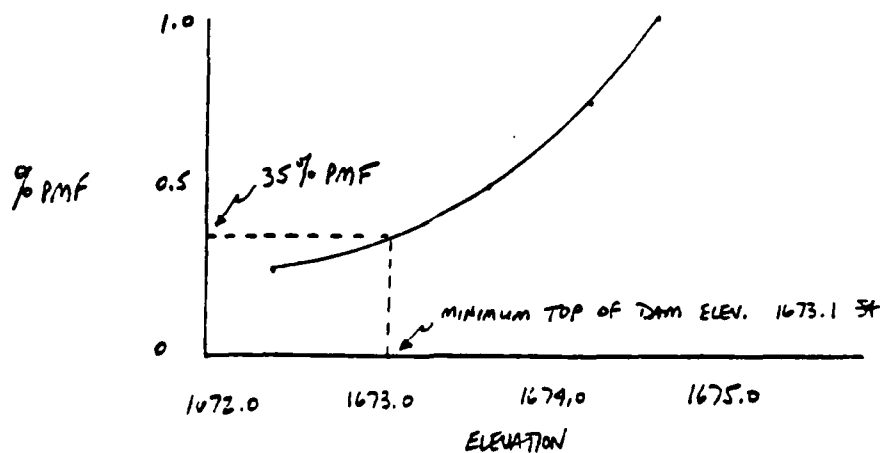
DISCHARGE COEFFICIENTS, C (FROM BRATER & KING, HANDBOOK OF HYDRAULICS, P. 5-42)

HEAD, ft	C
0.5	4.14
1.0	4.08
1.2	3.93
1.5	3.75

MAXIMUM HEAD ON WEIR = 3.4 ft
(BEFORE OVERTOPPING BEGINS)

USE $C = 3.75$

$$\begin{aligned} \text{SPILOWAY CAPACITY} &= CLH^{3/2} \\ &= 3.75 (60)(3.4)^{3/2} \\ &= 1410.59 \text{ CFS} \end{aligned}$$



 FLOOD HYDROGRAPH PACKAGE (HEC-1)
 DAY SAF-TV VERSION JULY 1978
 LAST MODIFICATION 26 FEB 79
 48J UPDATE 04 JUN 79

NATIONAL PROGRAM FOR INSPECTION OF NON-FEDERAL DAMS									
HYDROLOGIC AND HYDRAULIC ANALYSES OF LIGONIER DAM									
UNIT HYDROGRAPH BY SNYDERS METHOD									
1	A1	0	0	0	0	0	0	0	0
2	A2	0	0	0	0	0	0	0	0
3	A3	0	0	0	0	0	0	0	0
4	B	300	10	0	0	0	0	0	0
5	B1	5	1	0	0	0	0	0	0
6	J	1	4	0.75	0.50	0.25	0	0	0
7	J1	1.0	1	0.75	0.50	0.25	0	0	0
8	K	0	1	0.75	0.50	0.25	0	0	0
9	K1	0	1	0.75	0.50	0.25	0	0	0
10	M	1	1	2.46	1.02	120.	130.	140.	1.0 0.05
11	P	23.9	102.	120.	130.	140.	1.0	0.05	0
12	T	2.76	0.45	2.0	1	1	1	1	1
13	X	-1.5	-0.05	2.0	1	1	1	1	1
14	X	-1.5	-0.05	2.0	1	1	1	1	1
15	K	1	2	ROUTING FOR LIGONIER DAM	1	1	1	1	1
16	K1	1	2	ROUTING FOR LIGONIER DAM	1	1	1	1	1
17	Y	1	1	ROUTING FOR LIGONIER DAM	1	1	1	1	1
18	Y1	1	1	ROUTING FOR LIGONIER DAM	1	1	1	1	1
19	SA	4.90	5.20	6.12	11.33	-1669.7			
20	SE	1660.7	1669.7	1680.0	1700.0				
21	SI	1669.7	60.	3.75	1.5				
22	SO	1673.1	2.65	1.5	458.				
23	SL	0	42	136	187				
24	SV	1673.1	1673.2	1673.3	1673.5	1673.8	1674.0	1674.5	1675.0
25	K	99				310	410	412	455
						1676.0	1676.0	1676.0	1678.0
									486

RUN DATE 03/24/80
TIME 13.54

NOT A SPECIFICATION.

NO	NHR	NMIN	IDAY	IHR	IMIN	METAC	IPLT	IPKT	INSTAN
300	0	10	0	0	0	0	0	-4	0

81195- 1.00 0.75 0.50 0.25
MULTI-PLAN ANALYSES TO BE PERFORMED
NPLAN= 1 NR110= 4 LR110= 1

SUB-AREA RUNOFF COMPUTATION

RUNOFF HYDROGRAPH TO DAM

ISTAQ	IComp	IECON	ITAPE	JPLI	JPRY	INAME	ISTAGE	IAUTO
1	0	0	0	0	0	1	0	0

HYDROGRAPH DATA

	TUNG	TAREA	SNAF	TRSDA	TRSPC	RATIO	LSNOW	LSAME	LOCAL
BHYDGG	I	2.96	0.0	2.96	0.0	0.0	0	0	0

PRECIP DATA

R6	R12	R24	R48	R72	R96
02.00	120.00	130.00	140.00	0.0	0.0

TRSPC COMPUTED BY THE PROGRAM IS 0.800

LOSS DATA

LUSS DATA										
DLROPT	STAKA	DLTKR	RTIOL	ERAIN	STKRS	RTIOK	STNTL	UNSTL	ALSMX	HTIMP
—	0.0	0.0	1.00	0.0	0.0	1.00	1.00	0.05	0.0	0.0

UNIT HYDROGRAPH DATA

IP= 2.76 CP=0.45 NTA= 0

RECESSION DATA

SYB14= -1.20 QDCSN= -0.05 RTUH= 2.00
RECESSION DATA

UNIT HYDROGRAPHIC END-OF-PERIOD ORIGINATES, LAG= 2.78 HOURS, CP= 0.45 WUL= 0.97									
3.	13.	27.	44.	64.	82.	107.	131.	156.	180.
220.	201.	236.	249.	258.	264.	266.	261.	242.	242.
233.	225.	216.	208.	200.	193.	186.	179.	172.	166.
160.	154.	148.	142.	137.	132.	127.	122.	118.	113.

MO-DA	HR-MN	PERIOD	RAIN	EXCS	LOSS	END-OF-PERIOD FLOW		MU-DA	HR-MN	PERIOD	RAIN	EXCS	LOSS	LUMP Q
109.	75.	105.	101.	97.	94.	90.	87.	84.	81.	78.				
51.	49.	47.	46.	44.	42.	40.	39.	38.	36.	35.				
35.	34.	32.	31.	30.	29.	28.	27.	26.	25.	24.				
24.	23.	22.	21.	20.	19.	18.	17.	16.	15.	14.				
10.	10.	15.	15.	15.	14.	13.	12.	11.	10.	9.				
SUM 20.77 24.35 2.42 204000.														
(680.16 618.16 61.86 5710.04)														

HYDROGRAPH ROUTING

ROUTING FOR LIGNIER DAM

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRK	INAME	ISTAGE	IAUTU
2	1	0	0	0	0	1	0	0
QLOSS	CLOSS	AVG	IRCS	ISAME	IUPF	IPMP	LSIR	
0.0	0.0	0.0	1	1	0	0	0	
MSIPS	MSIDL	LAG	AMSKK	X	ISK	STUKA	ISPRAT	
1	0	0	0.0	0.0	0.0	-1670.	0	

SURFACE AREA= 5. 5. 6. 11.
 CAPACITY= 0. 45. 104. 276.
 ELEVATION= 1661. 1670. 1680. 1700.

NOTE: A DAMPED VALUE OF
 458 FT. IS USED FOR
 THE OVERTOPPING ANALYSIS.
 THIS IS THE LENGTH OF DAM
 CREST WHICH IS SUBJECT
 TO ACTIVE OVERTOPPING

TOPEL	COQD	EXPD	DAMWID
1673.1	2.0	1.5	458.

CREST LENGTH AT OR BELOW ELEVATION 1673.1 1673.2 1673.3 1673.4 1673.5 1673.6 1674.0 1674.5 1675.0 1676.0 1678.0
 0. 42. 136. 187. 310. 410. 412. 455. 467. 486.

PEAK OUTFLOW IS 4110. AT TIME 42.50 HOURS

PEAK OUTFLOW IS 3083. AT TIME 42.50 HOURS

PEAK OUTFLOW IS 2055. AT TIME 42.50 HOURS

PEAK OUTFLOW IS 1026. AT TIME 42.50 HOURS

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
 FLOWS IN CUBIC FEET PER SECOND (CFS) METERS PER SECOND
 AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO	1	RATIO	2	RATIO	3	RATIO	4	RATIO	5	RATIOS APPLIED TO FLOWS	
														0.50	0.25
HYDROGRAPH AT	1	2.46	1	4109	3082	2055	1027								
	(	6.37)	(	116.36)	87.27)	58.18)	29.09)								
ROUTED TO	2	2.46	1	4110	3083	2055	1026								
	(	6.37)	(	116.39)	87.29)	58.19)	29.04)								

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1

RATIO OF PMF	MAXIMUM RESERVOIR W.S.-ELEV	ELEVATION STORAGE OUTFLOW	INITIAL VALUE 1669.70 45. 0.	SPILLWAY CREST 1669.70 45. 0.	TOP OF DAM 1673.10 66. 1411.	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
1.00	1674.69					72.	4110.	9.50	42.50	0.0
0.75	1674.29					70.	3083.	7.33	42.50	0.0
0.50	1673.76					67.	2055.	6.50	42.50	0.0
0.25	1672.45					60.	1026.	0.0	42.50	0.0

SHEET 10 OF 10

APPENDIX E

PLATES

CONTENTS

Plate 1 - Location Plan

Plate 2 - Watershed Map

Plate 3 - Location and Site Plans

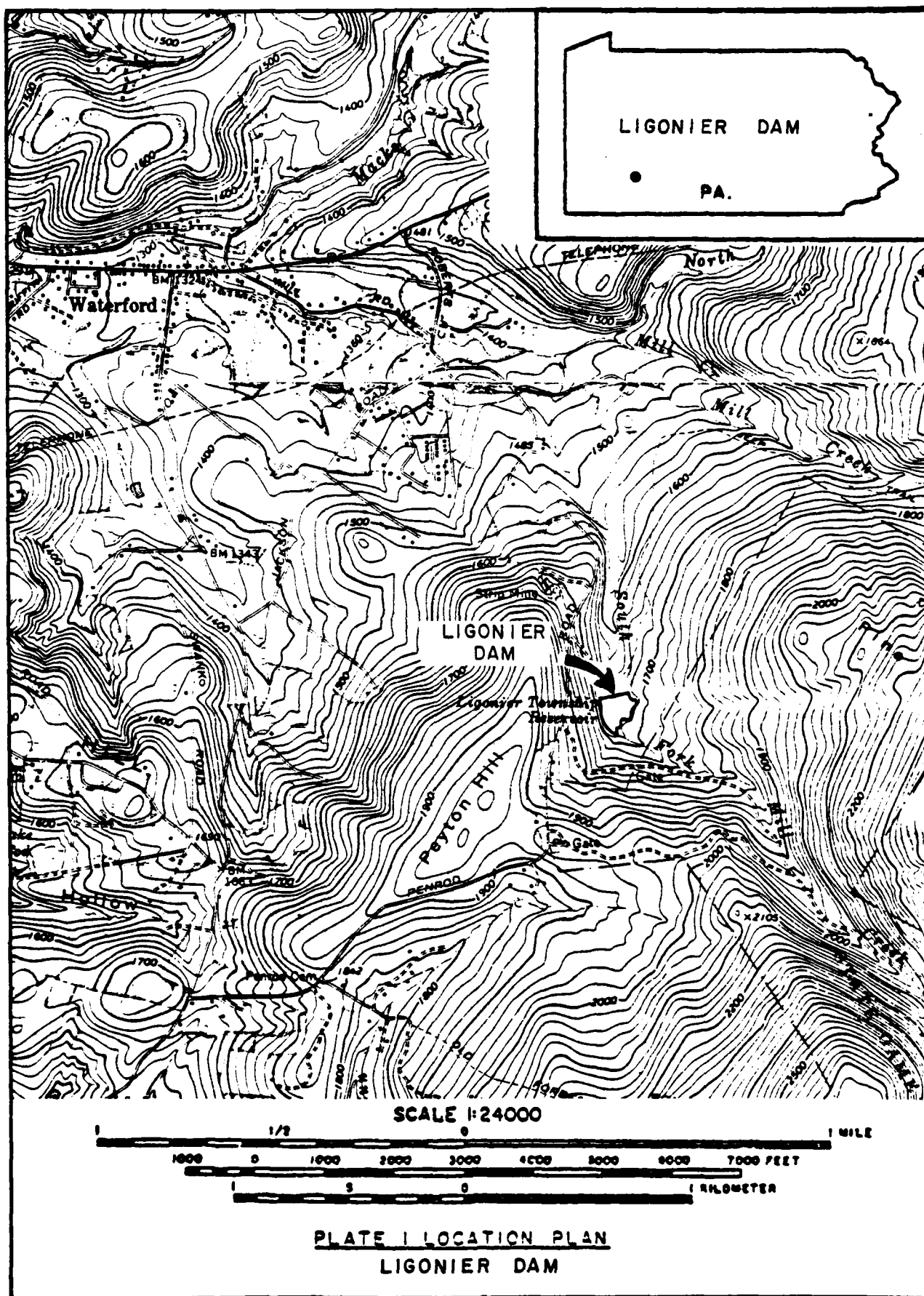
Plate 4 - General Plan of Dam

Plate 5 - Gate Tower and Sluiceway Details

Plate 6 - Spillway Details

Plate 7 - Embankment Sections

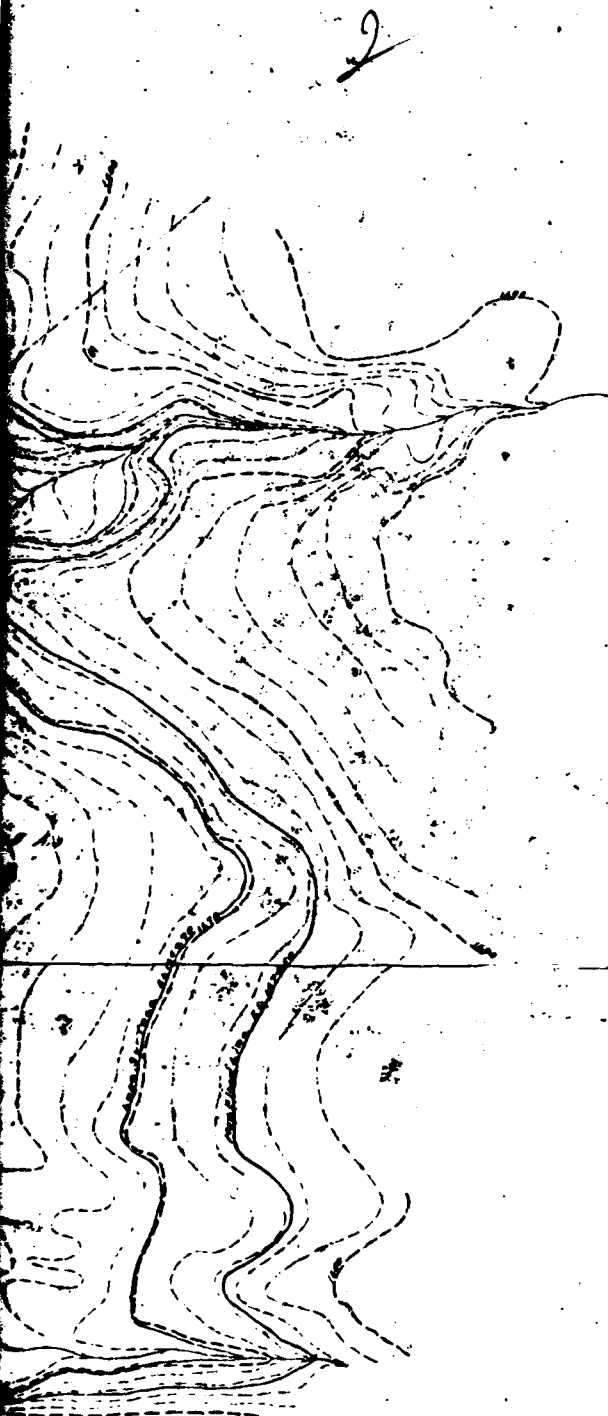
Plate 8 - Sections Through Spillway Overflow Channel and
Section Through Outlet Conduit



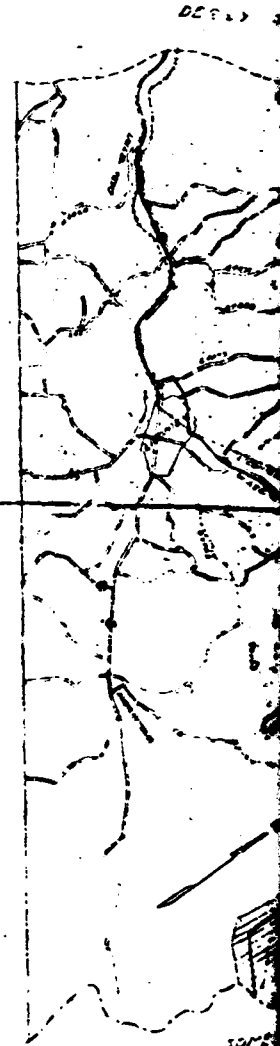


SITE PLAN
Scale 1"=40'

REVISED	THE
BY	DATE
	WATER
	LIGONIE
	W
	LOCAL
DESIGNED	
CHECKED	



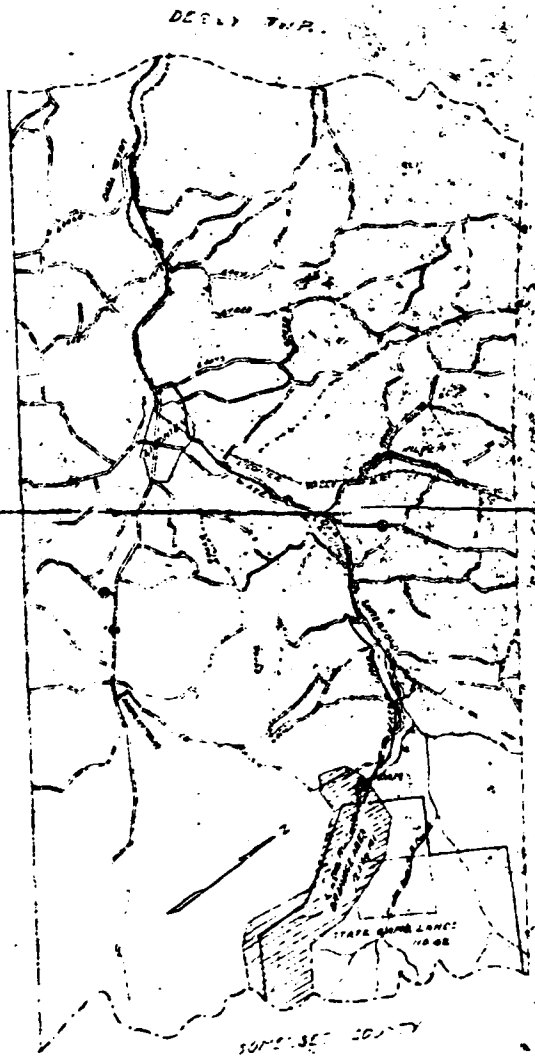
PENNA. STATE GAME LANDS 1902
WESTPHAL AND CO.



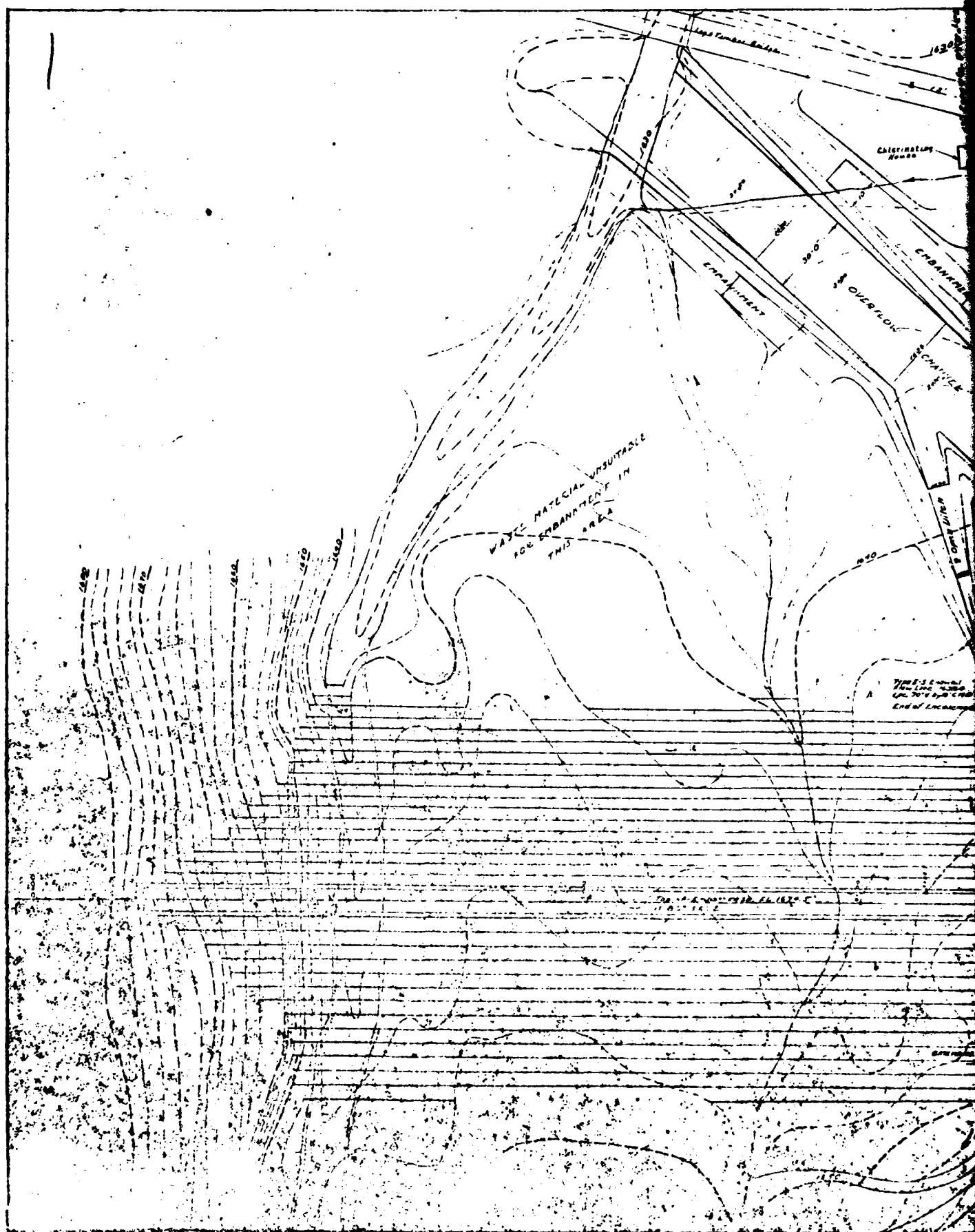
SITE PLAN
Scale 1"=40'

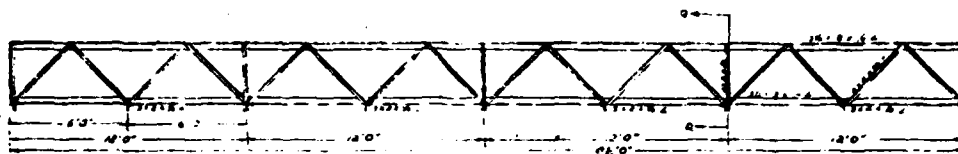
LIGONIE T. C. PLAN
LOCATION PLAN SHEET NO. 1
ALL TERRITORY FOR
Scale 1"

REVISED		THE NEILAN ENGINEERS	
BY DATE		SOMERSET, PENNA.	
		WATER SUPPLY SYSTEM	
		FOR	
		LIGONIER TWP. MUN. AUTHORITY	
		WESTMORELAND CO., PA.	
		LOCATION & SITE PLANS	
DESIGNED BY FGH		DATE 5-8-52	SHEET NO.
CHECKED BY		RPE:G2B1	3
SCALE - As shown			

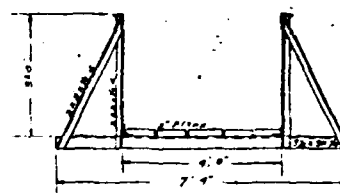
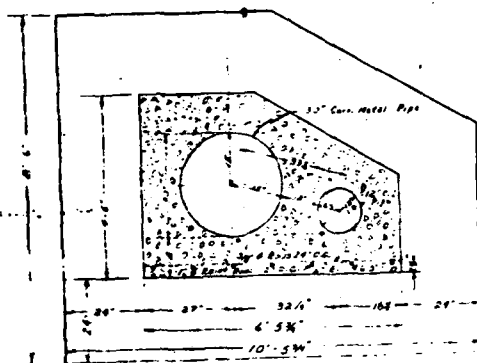


LIGONIER TWP. MUN. AUTHORITY
 LOCATION PLAN SHOWING DRAINAGE AREA
 AND TERRITORY SERVED
 Scale 1"=1 mi.

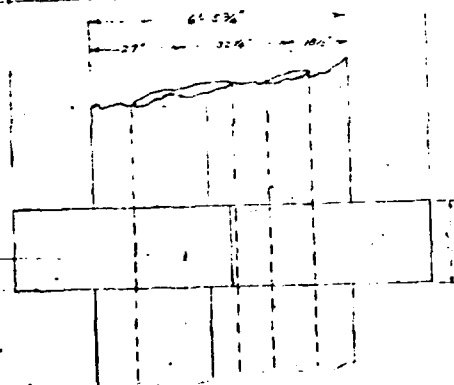




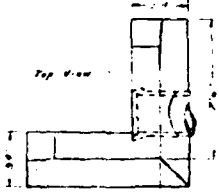
Highway Truss



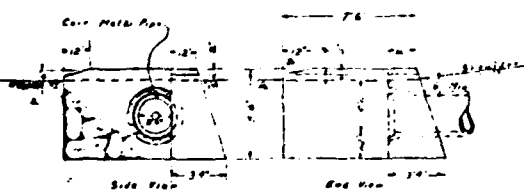
Section D-D
At Quarter Section & Duff Bed



SECTION C-C (See General Notes)
ENCASING OF OUTLET PIPES SHOWN



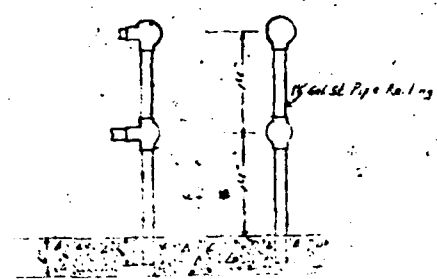
Top View



Side View

End View

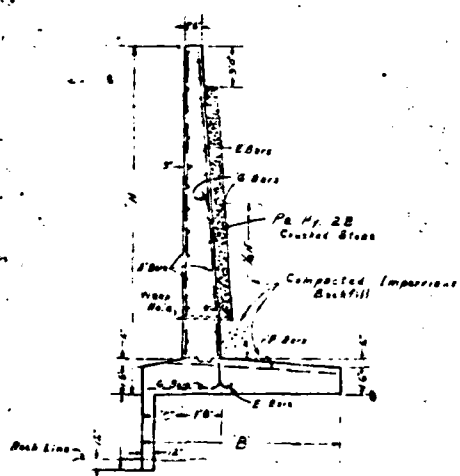
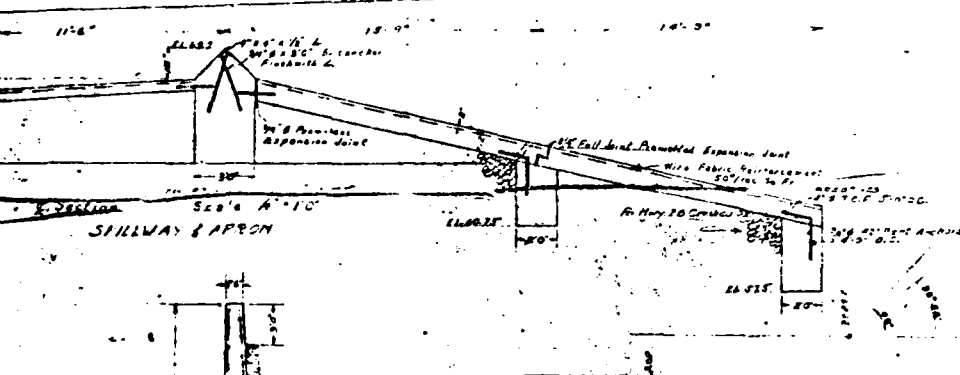
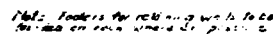
TYPE E-5 EXHAUST
NO. 1-2



DETAIL OF PIPE RAILING
Not To Scale

PLATE 5

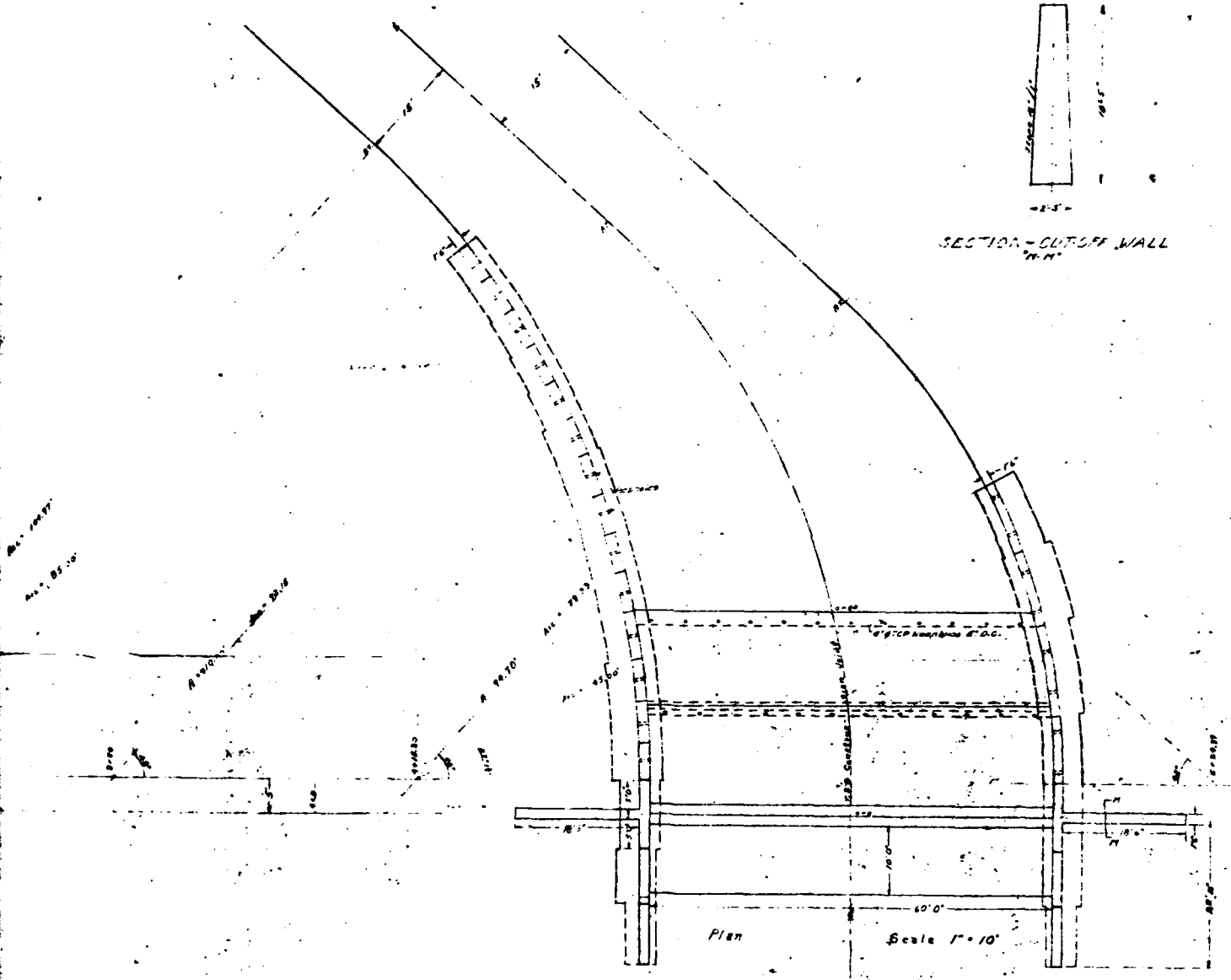
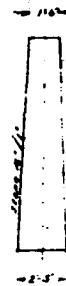
REVISED	BY	DATE	THE NEILAN ENGINEERS
			SOMERSET, PENNA.
			WATER SUPPLY SYSTEM
			FOR
			LIGONIER TWP. MUN. AUTHORITY
			WESTMORELAND CO. PA.
			GATE TOWER & SIDEWAY DETAILS
			DESIGNED BY RPE DATE 5-1-12 SHEET NO.
			CHECKED BY RPE 6251
			SCALE 1/2" = 1'-0"



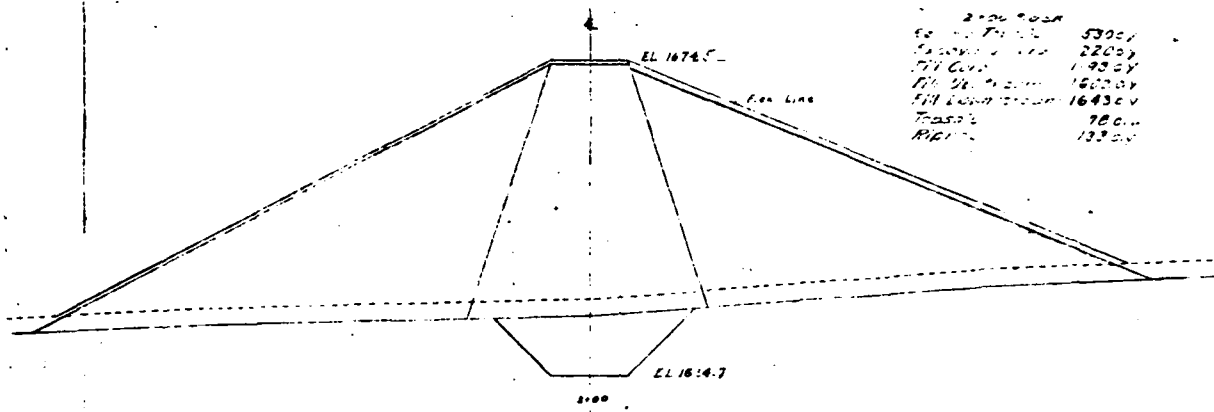
Section - Retaining Wall
Not to scale

[illegible]

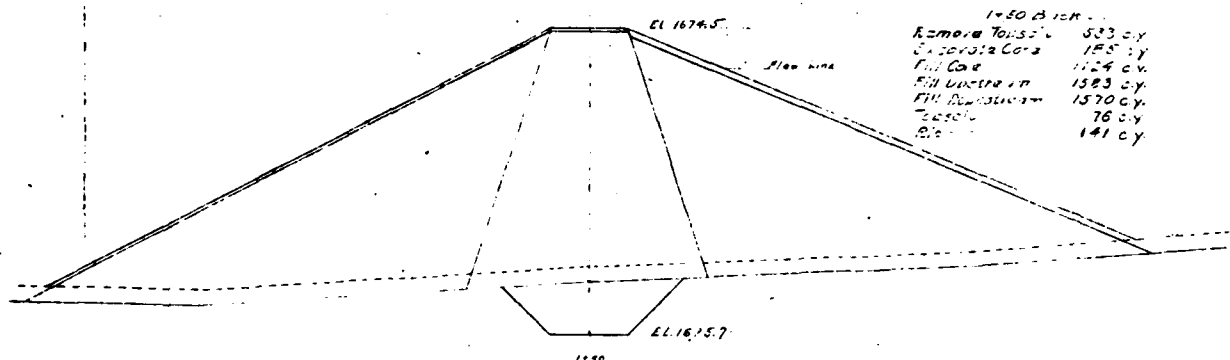
2

[illegible]

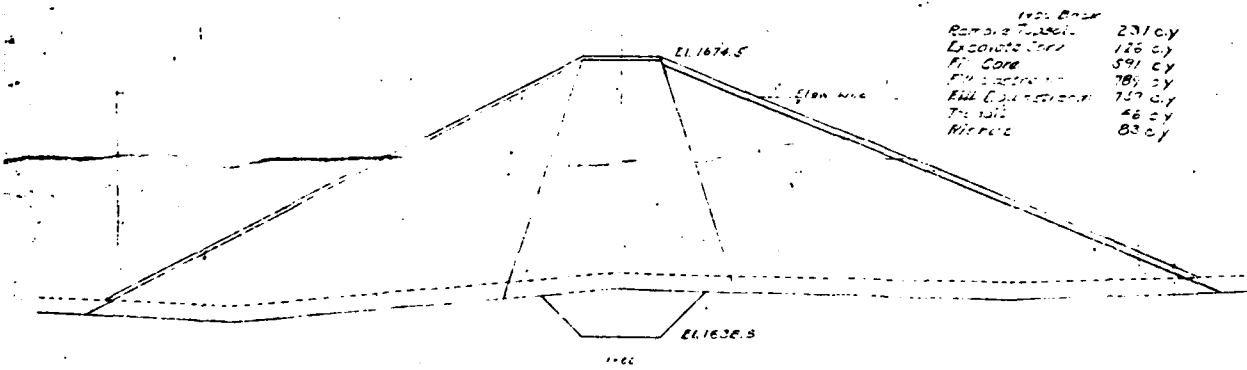
REVISED		DATE		SHEET NO.	
BY	DATE	THE NEILAN ENGINEERS		6	
		SOMERSET, PENNA.			
		WATER SUPPLY SYSTEM			
		FOR			
		LIGONIER TWP. MUN. AUTHORITY			
		WESTMORELAND CO. PA.			
		SPILLWAY DETAILS			
		DESIGNED BY F. M.	DATE 5/5/52	SHEET NO.	
		CHECKED BY	RPE 8251	6	
		SCALE: As Shown			



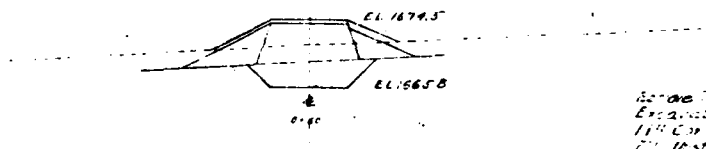
Remove Topsoil	530 cy
Excavate Core	220 cy
Fill Core	1490 cy
Fill Upstream	1600 cy
Fill Downstream	1643 cy
Grass	76 cy
Riprap	133 cy



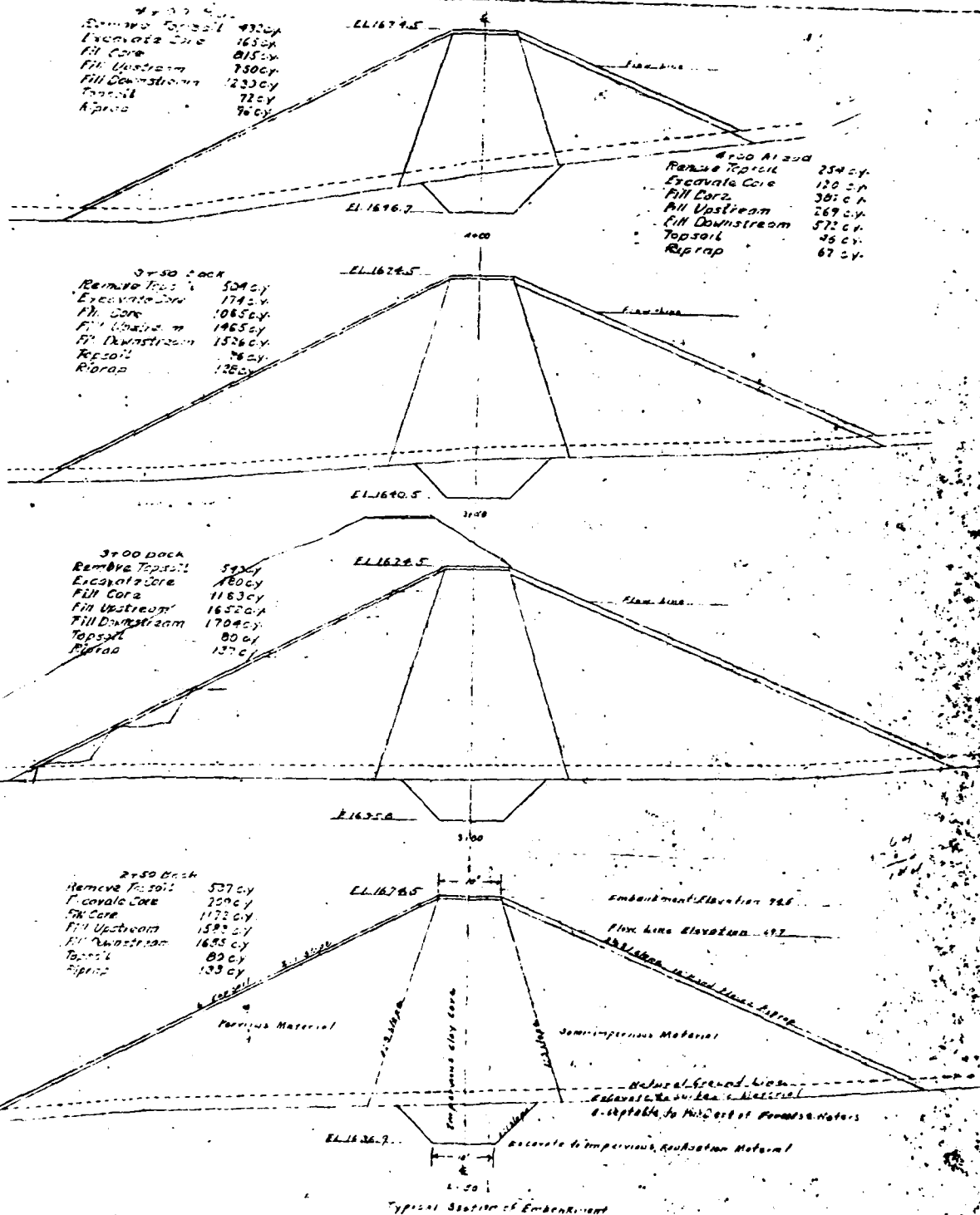
Remove Topsoil	533 cy
Excavate Core	185 cy
Fill Core	1124 cy
Fill Upstream	1583 cy
Fill Downstream	1570 cy
Grass	76 cy
Riprap	141 cy



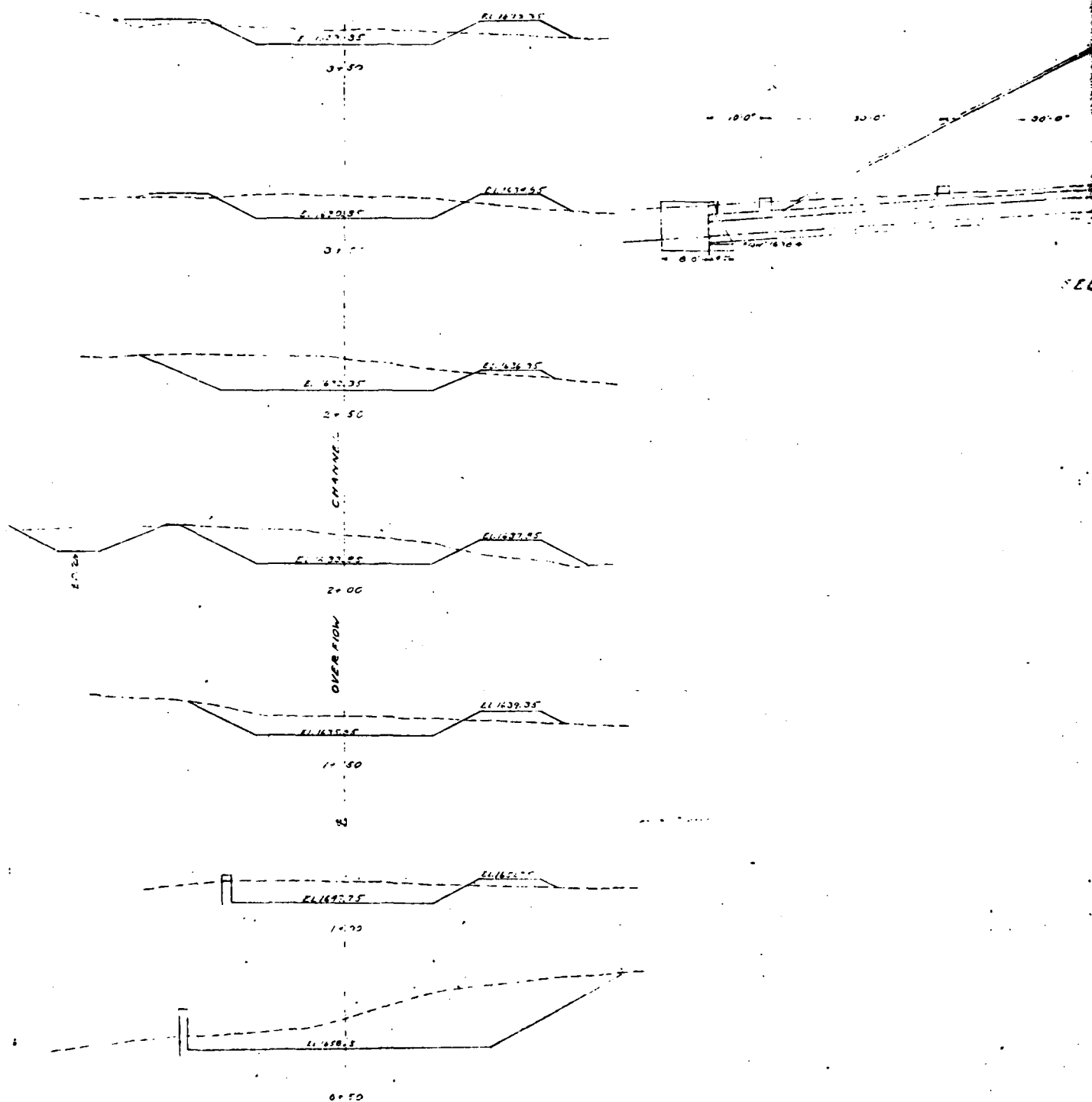
Remove Topsoil	231 cy
Excavate Core	126 cy
Fill Core	591 cy
Fill Upstream	789 cy
Fill Downstream	757 cy
Grass	48 cy
Riprap	83 cy



Remove Topsoil	52 cy
Excavate Core	16 cy
Fill Core	20 cy
Fill Upstream	5 cy
Fill Downstream	4 cy
Grass	5 cy
Riprap	5 cy

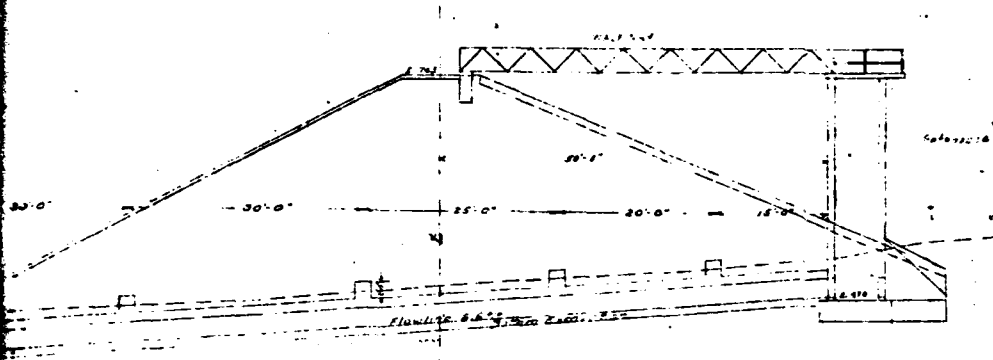


REVISED		THE NEILAN ENGINEERS	
BY	DATE	SOMERSET, PENNA.	
		WATER SUPPLY SYSTEM	
		FOR	
		LIGONIER TWP. MUN. AUTHORITY	
		WESTMORELAND CO. PA.	
		EMBANKMENT SECTIONS	
		DESIGNED BY	DATE 5-5-72
		CHECKED BY	RPE 6281
		SCALE	1" = 10'
			SHEET NO. 2



SECTIONAL OVERFLOW CHANNEL
 SCALE 1" = 10'

REVISED		THE NEILAN ENGINEERS	
BY	DATE	SONERSET, PENNA.	
		WATER SUPPLY SYSTEM	
		FOR	
		LIGONIER TWP. MUN. AUTHORITY	
		WESTMORELAND CO. PA.	
		SECTION 3 - OVERFLOW CHANNEL	
		OUTLET	
DESIGNED BY	DATE	5-5-52	SHEET NO.
CHECKED BY		RPE 6281	8
SCALE			



SECTION THRU OUTLET
SCALE 1" = 10'

30'
25'
20'
15'
10'
5'

APPENDIX F

REGIONAL GEOLOGY

LIGONIER DAM
NDI No. PA 00477, PennDER No. 65-117

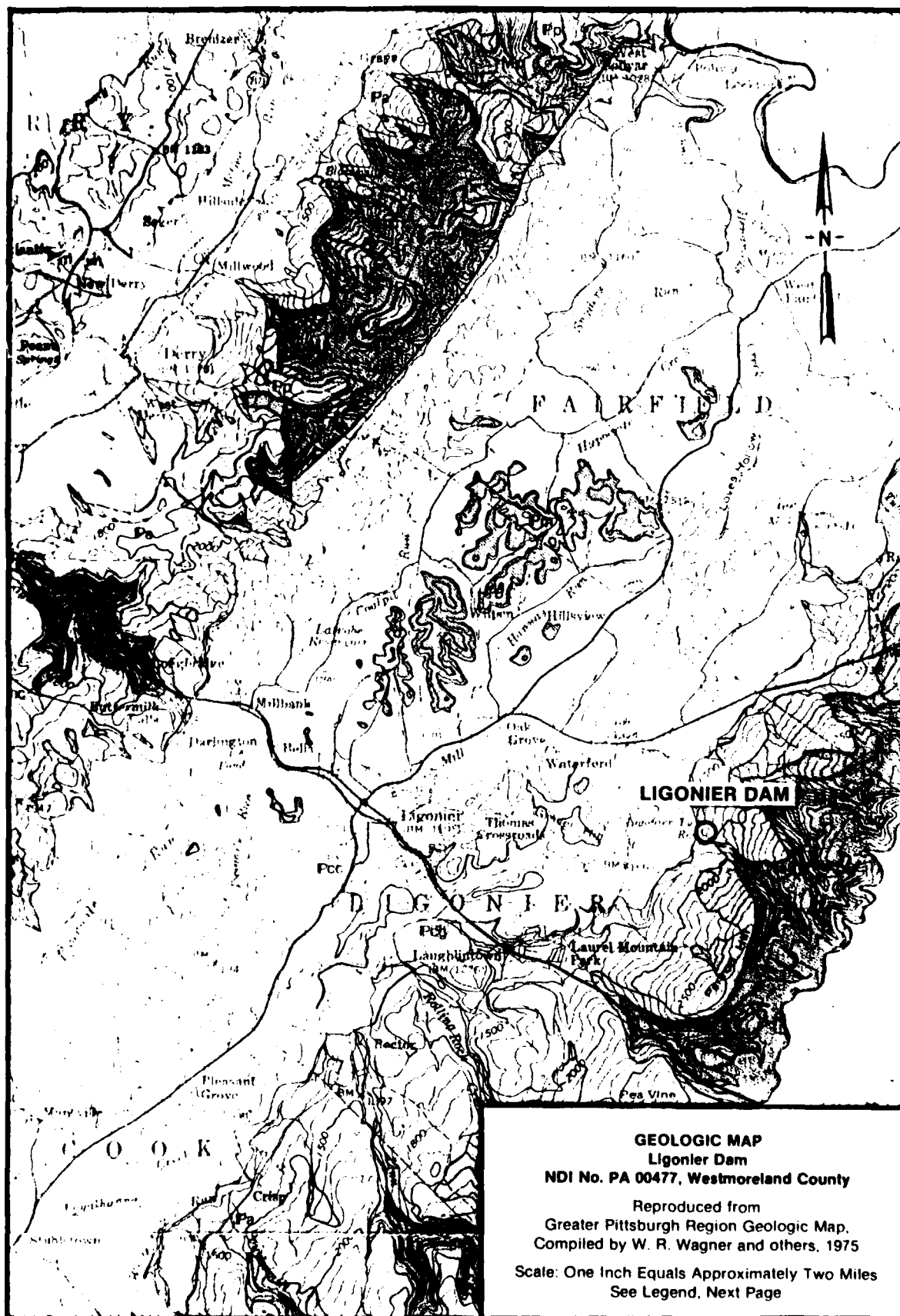
REGIONAL GEOLOGY

Ligonier Dam is located in an unglaciated section of the Appalachian Plateaus Physiographic Province. Bedrock units below the dam (as shown on the geologic map) are members of the Allegheny Group, Pennsylvanian System. These members consist of cyclic sequences of shale, sandstone, limestone, and coal¹. Other references² indicate that the right portion of the dam may be located on the Homewood Sandstone of the Pottsville Group, Pennsylvanian System. The Homewood Sandstone is known to yield considerable quantities of water and is the source of springs in the general area. Bedrock dips steeply (approximately 1000 feet per mile) from the Laurel Hill Anticline northwest to the Ligonier Syncline.

The Brookville coal marks the contact between the Allegheny and Pottsville groups. The presence and thickness of the coal locally has only been inferred and the coal has not been mined very much except for a few minor striping operations to the north. No site borings or test pits were available for review for the regional geology.

¹Reference: "Greater Pittsburgh Region Geologic Map," compiled by W.R. Wagner and others, 1975.

²"Geology and Mineral Resources of the New Florence Quadrangle, Pennsylvania," by M.N. Shaffner, Pennsylvania Geological Survey, 1958.



GEOLOGY MAP LEGEND

GROUP FORMATION

DESCRIPTION

Alluvium		Ot.	Sand, gravel, clay.
Terrace deposits			Sand, clay, gravel on terraces above present rivers; includes Carmichaels Formation.
DUNKARD	Greene		Cyclic sequences of sandstone, shale, red beds, thin limestones and coals.
	Washington	Pw	Cyclic sequences of sandstone, shale, limestone, and coal; contains Washington coal bed at base.
	Waynesburg		Cyclic sequences of sandstone, shale, limestone and coal; contains Waynesburg coal bed at base.
MONONGAHELA		Pm	Cyclic sequences of shale, limestone, sandstone and coal; contains Pittsburgh coal bed at base.
P: CONEMAUGH	Casselman	Pcc	Cyclic sequence of sandstone, shale, red beds and thin limestone and coal.
	Ames		
	Glenshaw	Pcg	Cyclic sequences of sandstone, shale, red beds and thin limestone and coal; several fossiliferous limestone; Ames limestone bed at top.
ALLEGHENY	Vanport	Pa	Cyclic sequences of shale, sandstone, limestone, and coal; contains Brookville coal at base and Upper Freeport coal at top; within group are the commercial Vanport limestone and Kittanning and Clarion coals.
		Pa	
POTTSVILLE		Pp	Sandstone and shale; contains some conglomerate and locally mineable coal.
Mauch Chunk		Mmc	Red and green shale with some sandstone; contains Wymys Gap and Loyalhanna limestones.
Pocono		Mp	Sandstone and shale with Burgoon sandstone at top.

DATE
LME